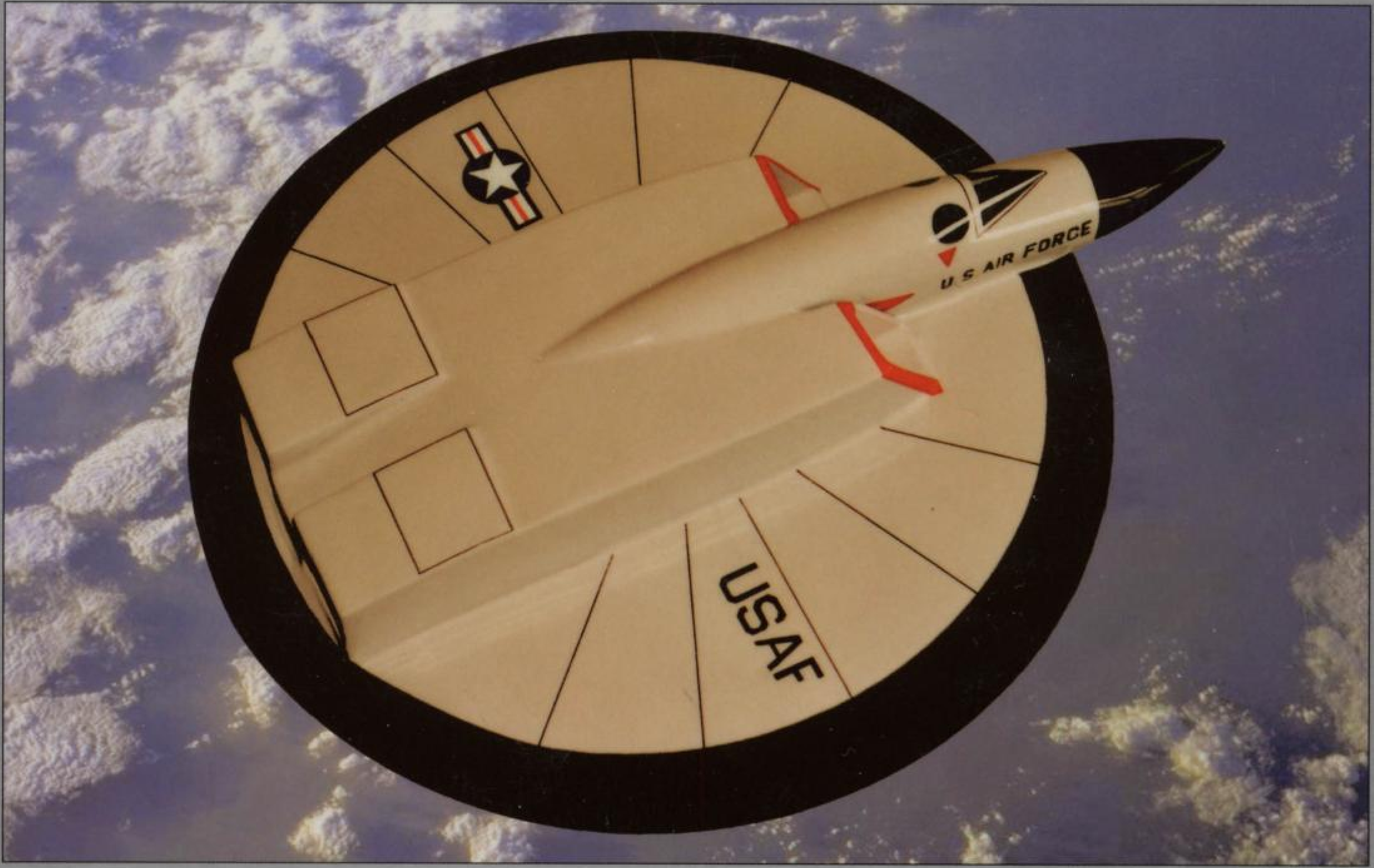
SECRET PROJECTS

FLYING SAUCER AIRCRAFT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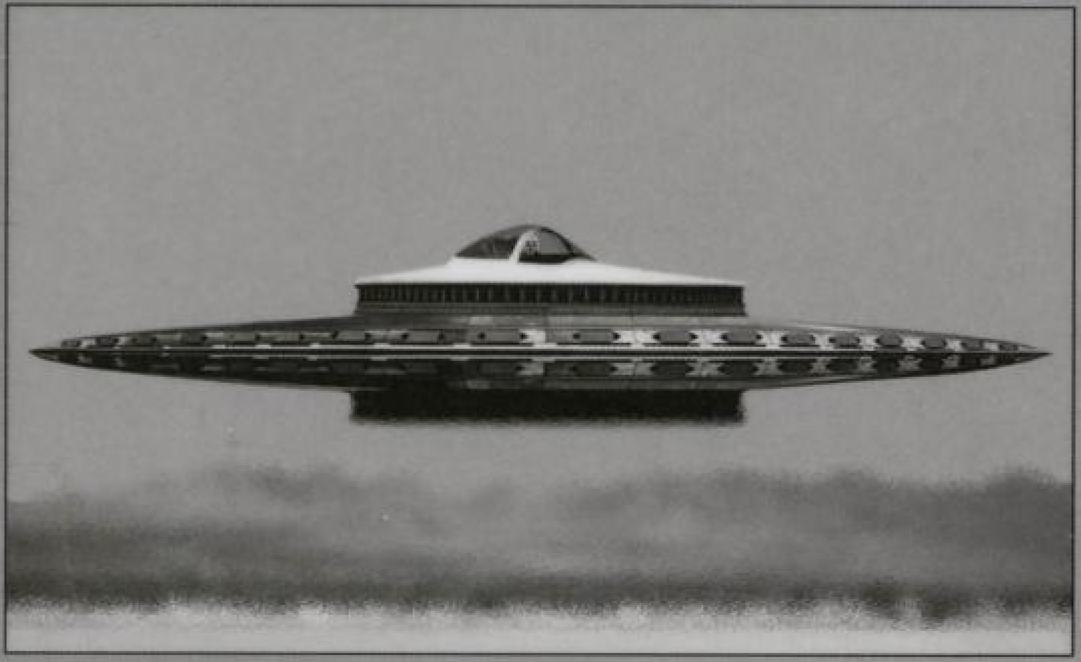

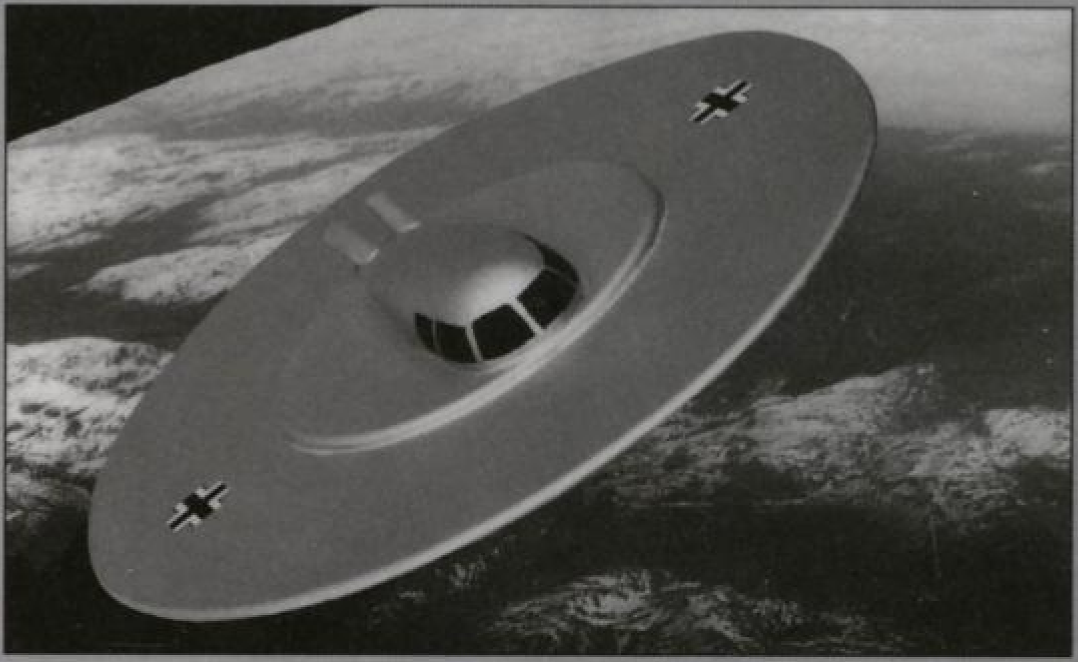

BILL ROSE & TONY BUTTLER

SECRET PROJECTS
FLYING SAUCER AIRCRAFT

There has for years been a great deal of speculation on whether flying saucers, and the aliens who are supposed to favour these as a form of transportation, have any basis in reality or are mere fantasies. What can be established is that over many decades experimental aircraft designs have been produced in different countries which can be described as being similar to flying saucers or flying wings. Such aircraft are usually shrouded in secrecy.

Some of these types were developed before and during World War Two though most date from the post-war era. The Pentagon spent millions with defence contractors on research and development in this field during the 1950s whilst later NASA got involved in funding this research.

This is the ultimate 'secret projects' book, and may well be the first non-fiction book on flying saucers! All of the craft featured in the book are grounded in reality and not fantasy.

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BILL ROSE & TONY BUTTLER

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Photograph on title page:
The details of this picture showing the Arup S-2 are not known, but the photograph is believed to show Snyder and Hoffman next to the aircraft.
via Bill Rose

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Introduction

'I can assure you that flying saucers, given that they exist, are not constructed by any power on earth'.

– US President Harry S Truman; White House Press Conference April 1950

Just mention the term 'Flying Saucer' during any conversation and you can be fairly certain it will conjure up images of an alien spacecraft. People inevitably visualise the kind of shiny flying discs that were portrayed in early 1950s Hollywood movies, such as *The Day The Earth Stood Still* or perhaps *Earth vs The Flying Saucers.* Science fiction films featuring flying saucers have closely reflected public curiosity about 'Unidentified Flying Object' (UFO) phenomena, which can be traced back to 24th June 1947 when an unexplained sighting took place in America's Washington State that helped to create an entirely new worldwide movement.

On the day in question, pilot Kenneth Arnold (1915-1984) was crossing the Cascade Mountains when he sighted what appeared to be nine semi-disc shaped objects in the distance. Arnold calculated that they were travelling at high supersonic speed and he was well aware that no military aircraft existed that was capable of breaking the sound barrier, let alone reaching or sustaining speeds in excess of Mach 2. After landing, Arnold filed a report, convinced that he had seen a formation of top-secret military aircraft on a test flight. Not surprisingly, the media picked up on this, wasting no time in promoting the idea that these mysterious craft had come from a distant world.

Arnold described the objects as behaving like 'saucers skipping across water' and this minor detail was fully utilised by a journalist called Bill Bequette who called them flying saucers. Although the term flying saucer was already in limited use, Bequette's report caught the public's imagination and the age of extraterrestrial visitation was born. Arnold was widely regarded as a highly credible witness and nobody could really fault his sighting. Nevertheless, it is hard to imagine how he was able to see any object detail at ranges quoted as 25-100 miles (40-160km), which was a factor picked up by professional investigators like Dr J Allan Hynek (1910-1986) and Dr Donald H Menzel (1901-1976).

In 1997, researcher Philip Klass (1919-2005) came up with a convincing theory that Arnold had seen falling meteor fragments and a couple of years later James Easton suggested that Arnold's UFOs were probably nearby white pelicans, although this proposal was treated with total ridicule by most of the believers in an alien presence on Earth.

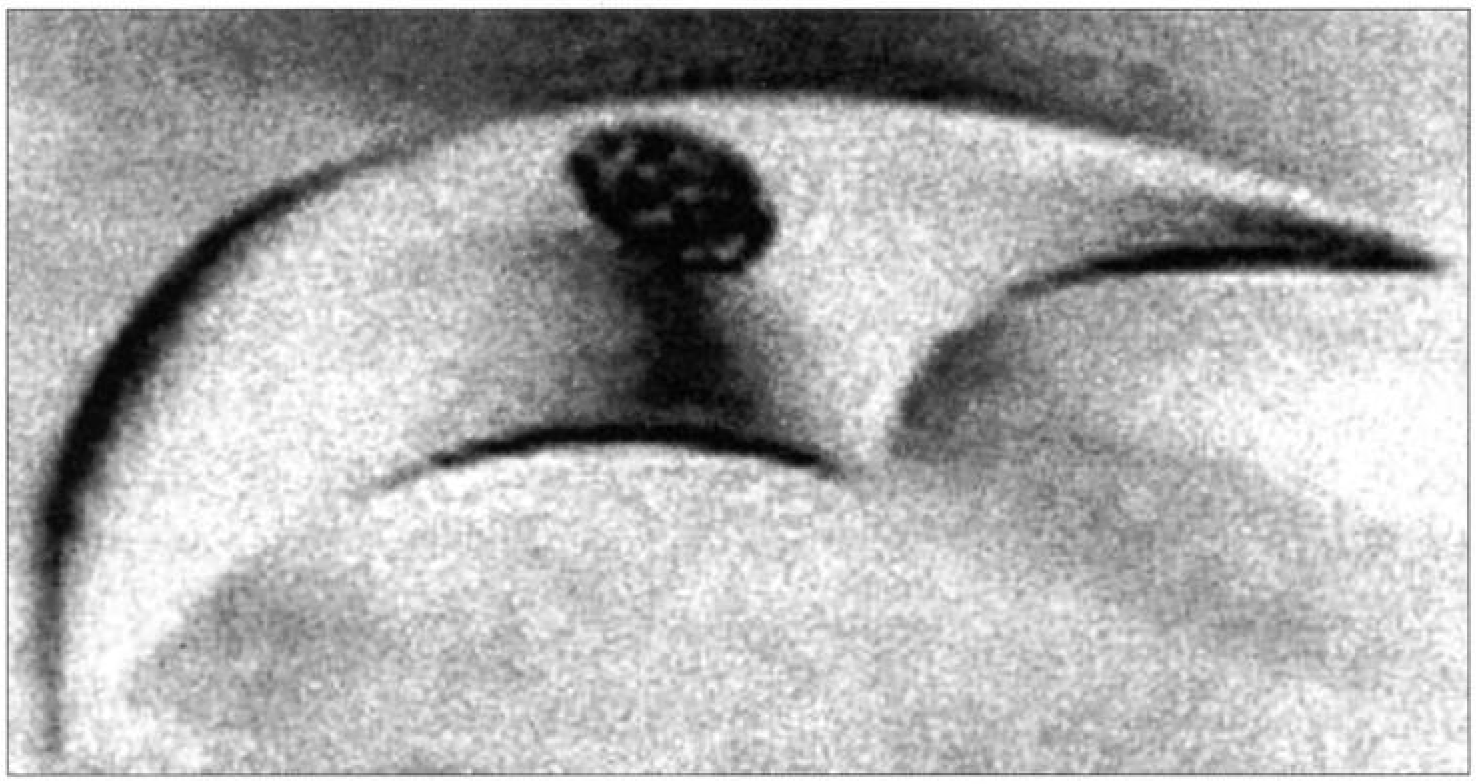


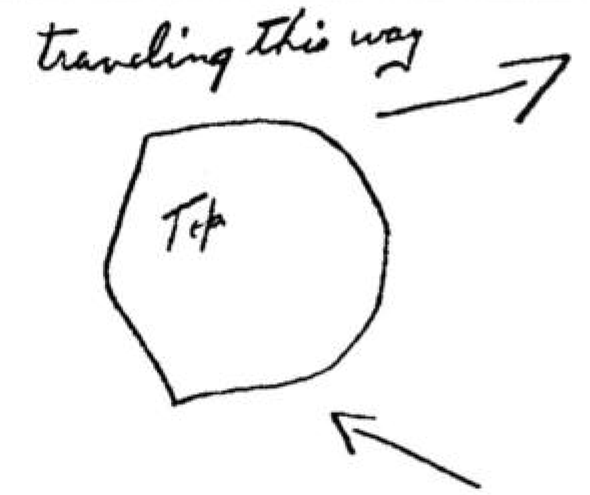
Illustration of one of the UFOs allegedly sighted by Kenneth Arnold in 1947. The crescent shape is an artist's interpretation of what Arnold saw. via Bill Rose

Kenneth Arnold holds an illustration of (one of nine) mysterious craft he claimed to have sighted crossing the Cascade Mountains, Washington State in 1947. The crescent shape is somewhat at odds with his account of the sighting and appears to be an artist's visualisation. However this event was responsible for creating worldwide interest in UFOs. via Bill Rose

Exactly what it was that Arnold observed remains a mystery that may never be resolved, but the Cascade Sighting was swiftly followed by the infamous Roswell Incident, which many believe to have been the crash of an extraterrestrial flying saucer and the subsequent recovery of exotic debris and several alien bodies by the USAAF.

On 3rd July 1947, William 'Mac' Brazel, who managed the J B Foster Ranch near Corona, New Mexico discovered a quantity of unusual debris spread across a field, which he took to be the fresh remains of an aircraft that had exploded in mid-air. He reported this to the authorities in nearby Roswell, who contacted the USAAF. They carried out an investigation and several days later made a startling announcement that a flying saucer had been recovered. As the ramifications of this astonishingly ill-considered press release became apparent, senior USAAF officials began to panic and insisted they had found nothing more than a weather balloon. Public interest finally waned and the story was largely forgotten until 1994, when Congressman Steven Schiff forced the USAF to reopen the Roswell Case.

Drawing made for USAAF Intelligence by Kenneth Arnold, showing one of the UFOs he claimed to have sighted in 1947. The shape produced for this official report is rounder and somewhat different to the early crescent image portrayed by the popular media. via Bill Rose

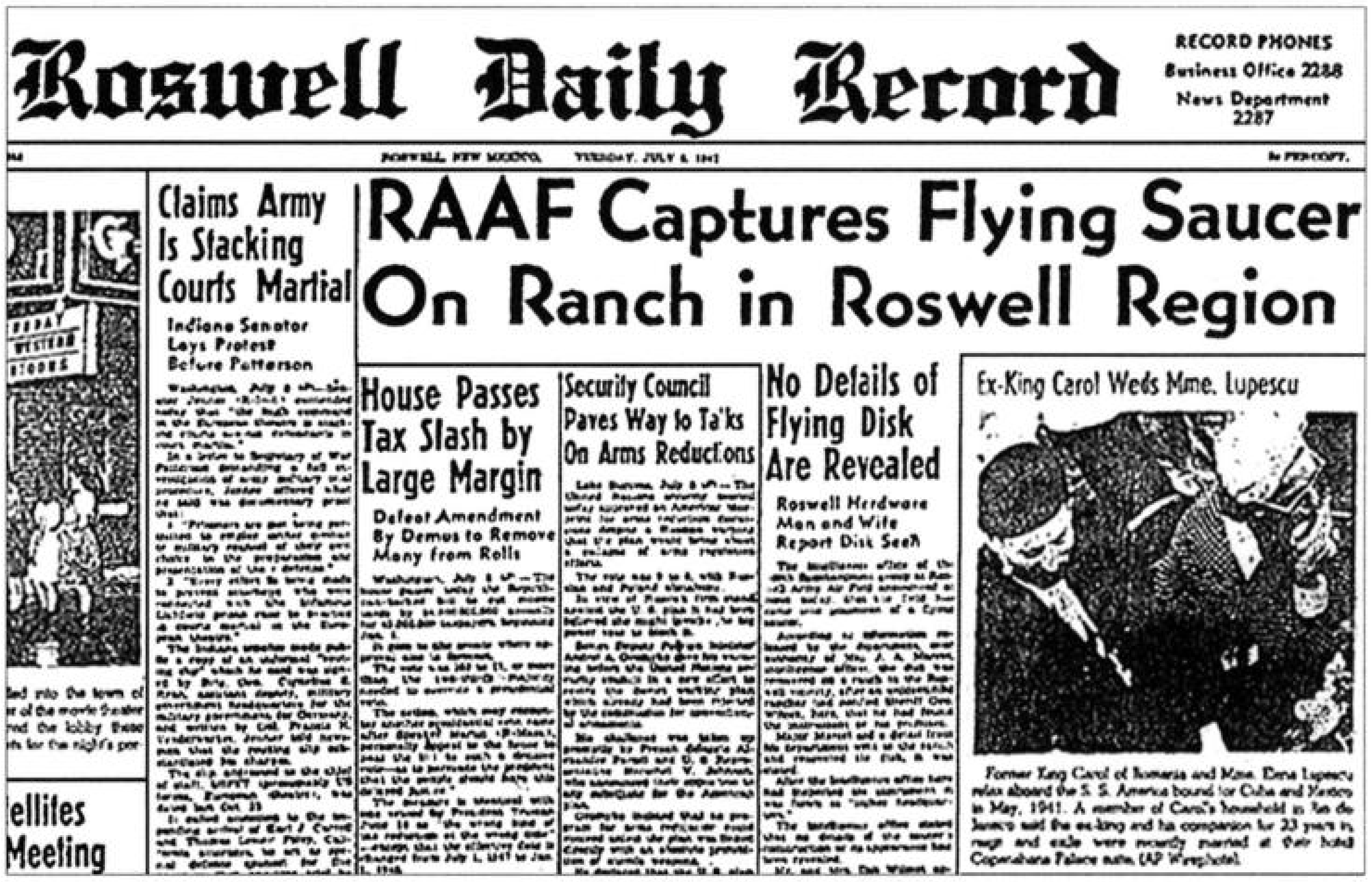


They seemed longer than wide, their thickness was about 1/20th of their width

Mirror Bright

They did not appear to me to whirl or spin but seemed in fixed position, traveling as I have made drawing.

Front page of the *Roswell Daily Record* newspaper 6th July 1947, announcing 'RAAF Captures Flying Saucer'. The Roswell Daily Record – used with their written permission



Roswell Daily Record

RECORD PHONES
Business Office 2288
News Department
2287

RAAF Captures Flying Saucer On Ranch in Roswell Region

Claims Army Is Stacking Courts Martial

Indiana Senator Lays Protest Before Patterson

House Passes Tax Slash by Large Margin

Defeat Amendment By Demos to Remove Many from Rolls

Security Council Paves Way to Talks On Arms Reductions

No Details of Flying Disk Are Revealed

Roswell Hardware Man and Wife Report Disk Seen

Ex-King Carol Weds Mme. Lupescu

ellites Meeting

The USAF reluctantly acknowledged that a cover-up had taken place, but stuck with the original story, simply modifying the details to suggest that the object recovered was a top-secret balloon belonging to an operation called Project Mogul. Apparently, the Mogul balloon carried classified acoustic equipment designed to listen for Soviet nuclear explosions. Unfortunately, there are many flaws in this story and not surprisingly, the belief that an alien spacecraft crashed has persisted.

What happened near Roswell in 1947 remains a mystery to everyone outside the higher levels of Pentagon staff, who still seem unwilling to lose face over the issue. Conceivably it was the crash landing of a black project aircraft, an early *Broken Arrow* nuclear weapon accident or some kind of psychological warfare operation, but the debate continues.

Six months later, on 7th January 1948, four Kentucky Air National Guard P-51D Mustang fighters set out from Marietta AFB in Georgia. Their destination was Standiford AFB, Kentucky and the purpose of the journey was to deliver the aircraft to new USAF users. Captain Thomas 'Tommy' Francis Mantell led the flight in aircraft KY-869. About halfway through the journey he was contacted by the controller at Godman AFB, who asked him to investigate a large, bright, unidentified object which had been observed by dozens of people at the Kentucky towns of Madisonville, Irvington and Owensboro. For reasons involving fuel and/or oxygen, the rest of Mantell's flight soon abandoned the interception and continued on their journey, leaving Captain Mantell to climb towards the unknown object.

Like his colleagues, Mantell had not been supplied with oxygen because he was undertaking a short-distance ferry flight, but as an experienced World War Two combat veteran he should have fully understood the hazards of high-altitude operations. With the object in sight, Mantell radioed Godman Tower to report that, 'It appears to be a metallic object or possibly reflection of Sun from a metallic object, and it is of tremendous size'. The Mustang soon passed 22,000ft (6,705m) and Mantell continued to climb. Minutes later, his aircraft fell from the sky and slammed into the ground on Joe Phillips' farm, about 3 miles (4.8km) southwest of Franklin, Kentucky.

Within weeks of the fatal crash a string of sensational stories appeared in the tabloids. These suggested that Mantell had been shot down by a huge alien flying saucer equipped with a death ray, and his body was missing from the aircraft wreckage or strangely disfigured. In reality, he had almost certainly chased a Skyhook balloon launched from Camp Ripley, Minnesota on 6th January 1948, which was carried across Kentucky by the wind at very high altitude. Mantell probably lost consciousness due to anoxia (oxygen starvation) at an altitude of around 25,000ft (7,620m), and then the P-51D briefly levelled off at about 30,000ft (9.144m) before plunging into a steep dive.

One further incident would establish the flying saucer's status with the UFO community as a clear-cut visitor from another world. Oregon farmer Paul Trent and his wife Evelyn claimed to have observed a flying disc crossing their property near McMinnville during the early evening of 11th May 1950. Paul Trent secured two photographs with his Roamer roll-film camera and, like Kenneth Arnold, the Trents suggested they had observed something secret belonging to the US military. The photographs were then passed to the McMinnville, Oregon Telephone Register newspaper, which gave them front-page coverage on 8th June 1950.

One week later, the national press picked up the story and this generated considerable publicity for the Trents, with many reports suggesting that the flying disc was an alien space-

Captain Thomas Mantell (Centre), who died while intercepting a high-altitude UFO over Kentucky in 1948. via Bill Rose

craft. All attempts to debunk these pictures failed and the Condon Committee (which was set up in the 1960s to investigate UFO phenomena) concluded that the McMinnville pictures were undoubtedly genuine. These images of a flying saucer were technically impressive and there was nothing to indicate that the Trents had the ability or will to generate a convincing hoax, or profit from it.

However, as time has passed, there has been a shift in opinion by serious investigators who now generally theorise that the object seen in both pictures was closer than previously assumed and may have been something hanging on an invisible wire, such as a hubcap or part of a lighting fixture. Detailed photometric analysis conducted by the astronomer Dr William K Hartmann from the University of Colorado indicated that the time of day when the pictures were taken was incorrect and that the period between each photograph was longer than claimed.

Unfortunately, the desire by certain individuals to create UFO hoaxes for reasons of fame or fortune has kept pace with interest in the subject and sometimes the simplest methods available have fooled the best-qualified experts. But whatever the explanation for the McMinnville sighting, an automatic association of flying saucers with extraterrestrials had become deeply embedded in much of the world's subconscious and the term UFO now meant alien spacecraft, as opposed to an unidentified flying object. Furthermore, the extraterrestrial hypothesis was being fuelled and maintained by the media, who had recognised its lucrative storytelling potential.

As the number of UFO sightings began to rise on both sides of the Atlantic, many US and European officials came to the conclusion that, although a good deal of public hysteria was responsible for creating this situation, some flying saucers might be sophisticated Soviet aircraft developed from captured Nazi technology. This was a time when the Cold War was particularly intense and, assuming the Russians were operating

Re-creation of the ill-fated P-51D Mustang fighter flown by Captain Thomas Mantell of the Kentucky Air National Guard during 1948. Bill Rose

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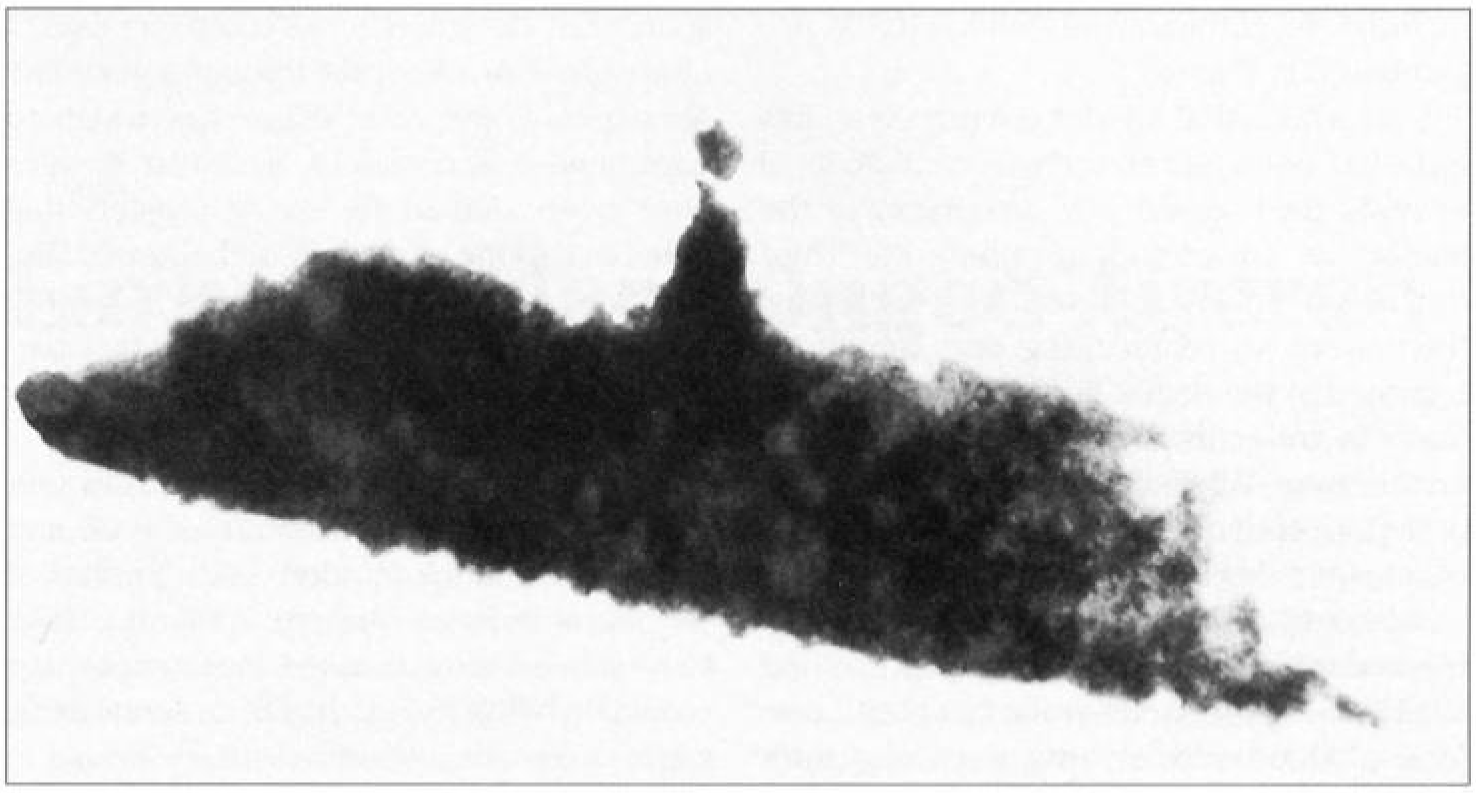


Selective enlargement of the McMinnville flying saucer, allegedly photographed on 11th May 1950 above the Trent's farm in Oregon. NICAP originally, via Bill Rose

new types of long-range aircraft to probe NATO air defences and conduct reconnaissance missions over sensitive military sites, it represented a new and very serious threat to Western security.

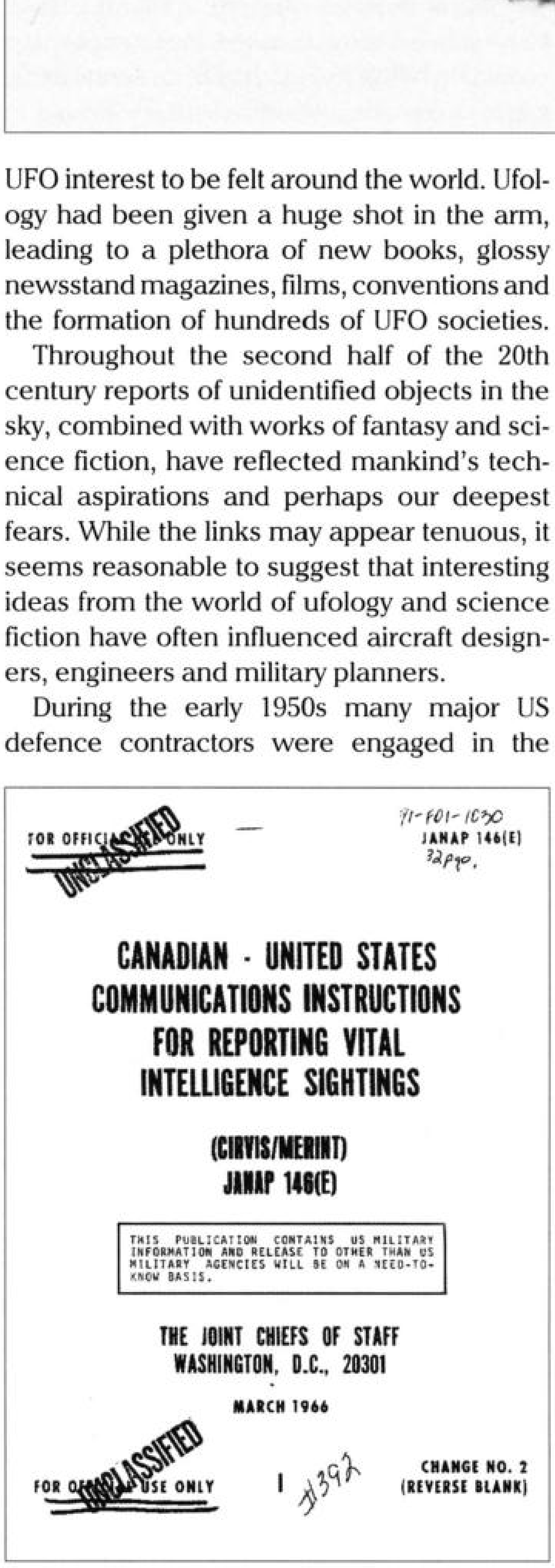
A typical example of this concern can be found in the December 1954 (Vol 7, Number 12) issue of Air Intelligence Digest, printed by the USAF's Directorate of Intelligence and originally classified secret. Dealing with future combat aircraft and flying discs, the publication had the following to say: 'One of the big questions now facing the United States is this: What are the Soviets doing in the disc-aircraft field? If the United States accepts the possibility of success of circular-shaped aircraft, then it must also conclude that the Soviet Union is capable of developing such aircraft. If readers assume, at the extreme end of the possibility scale, that the USSR is several years ahead right now, these questions must occur to them. If the Soviets now have such an aircraft in operational use, would the United States air defense system be able to detect, identify, intercept and destroy a bomber or reconnaissance aircraft moving at a 1,500 knot [2,780km/h] clip at an altitude of 65,000 feet [19,812m]?'

Senior Pentagon officials had also become alarmed by the sensational UFO reports appearing in the press and it was decided to take further action to halt what was regarded as another worrying problem. In 1954, an existing military directive called JANAP-146 (Joint Army, Navy and Air Force Publication) was applied to commercial pilots. JANAP-146 specified how military personnel should report unidentified flying objects and it was used as a tool of national security, which made unauthorised disclosure a serious offence. There were lasting protests within the airline industry, but this brought the flow of information from these sources to an abrupt halt.

Despite this step the public were now fully conditioned to the idea that flying saucers came from other planets and interest in UFOs continued throughout the 1950s, although it finally began to stagnate during the following decade and was then maintained by small groups of dedicated enthusiasts. When the Spielberg movie *Close Encounters of the Third Kind* was released in the late 1970s, something of a UFO revival took place, but it took the hugely popular 1990s TV sci-fi series *The X-Files*, to generate the next massive wave of UFO interest to be felt around the world. Ufology had been given a huge shot in the arm, leading to a plethora of new books, glossy newsstand magazines, films, conventions and the formation of hundreds of UFO societies.

Throughout the second half of the 20th century reports of unidentified objects in the sky, combined with works of fantasy and science fiction, have reflected mankind's technical aspirations and perhaps our deepest fears. While the links may appear tenuous, it seems reasonable to suggest that interesting ideas from the world of ufology and science fiction have often influenced aircraft designers, engineers and military planners.

During the early 1950s many major US defence contractors were engaged in the study and evaluation of the flying disc. The initial impetus may have come from advanced wartime aviation projects, but some designers were clearly intrigued by UFO reports and science fiction. A particularly good example was Avro-Canada's brilliant engineer John Frost who kept a personal scrapbook of UFO sightings and related material. Furthermore, some leading aircraft designers like Alfred Loedding, who worked for the USAF, and high-profile scientists like Thomas Townsend Brown became seriously involved in UFO investigation.



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FOR REPORTING VITAL
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THE JOINT CHIEFS OF STAFF
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JANAP-146E. This is a later version of the US military directive forbidding unauthorised disclosure of UFO sightings. US DoD

Today, the flying disc is still regarded as a contemporary cutting edge design, although there have been circular-shaped aircraft since the earliest days of manned flight and one design can be traced right back to the early 18th century. So far, this introduction has outlined the public's perception of the flying saucer, the ups and downs of ufology, links to the world of science fiction and military paranoia about Soviet developments. However, this book does not carry a detailed examination of these areas, because its purpose is to take a closer look at the unorthodox aviation and aerospace craft that fall within the general category of Man-Made Flying Saucers; it also features related designs including disc-shaped space vehicles. Although the majority of flying saucer concepts have never progressed beyond the drawing board, a small number have been built and flown.

Unfortunately, there are significant gaps in the historical detail of some projects and considerable effort has been made to avoid filling these sections with unreasonable speculation. Over a decade of research has gone into this book and there have been numerous trips up blind alleys and pointless detours along the way. Unquestionably, the most difficult part to write was the section dealing with German wartime flying discs, which includes the controversial Heinkel/BMW project based in Prague.

For reasons that are not entirely clear, this topic has been picked up by several political activists who regard any discussion of the subject as an attempt to glorify the Third Reich's technical achievements. In reality, there were no secret flying disc squadrons operated by the Nazi's, no clandestine saucer bases in Antarctica and definitely no facilities on the Moon! While the Germans were developing aerospace technology that was in some cases more than a decade ahead of anything possessed by the Allies, none of it had any significant influence on the outcome of World War Two. These small-scale flying disc projects (that led nowhere) were a far cry from the nonsensical stories that continue to circulate and multiply on the Internet.

Had this intriguing programme been undertaken by the ruthless wartime Japanese regime, or conducted within brutal Stalinist Russia, the issue would never have arisen. Perhaps significantly, one of the most advanced Vertical Take-off and Landing (VTOL) fighter concepts derived from German wartime research was built and flight-tested in France during the 1950s. But this continues to draw relatively little attention outside the country.

So what is it that makes aircraft with circular wings so attractive to designers? There are many reasons apart from a clean, aesthetically pleasing shape, which begins with the amount of lift that a disc shape can generate and the way a circular vehicle's internal space can be fully utilised. It is also true that the circular airframe lends itself to certain forms of propulsion like the ducted fan layout, an annular rotor, the radial flow gas turbine or various rather exotic field effect technologies. VTOL or good Short Take-off and Landing (STOL) performance at an improvised site or from a vessel is often a major factor with the military aircraft discussed in this book and the requirement has led to many unusual concepts.

Although drag becomes an issue with a large surface area, a flying disc can be configured for high-speed flight at substantial altitudes and may be capable of manoeuvres not possible with a conventional aircraft. As a spacecraft designed to re-enter the Earth's atmosphere or aerobrake through a planetary atmosphere, the disc shape has much to commend it and various lenticular designs have been studied for space projects that date back to the early days of the Apollo Programme. A lower radar signature is another consideration that makes the flying disc particularly interesting to designers looking for stealthy capabilities.

In 1994, while talking about stealth designs, the late Ben Rich (who became the boss at Lockheed's Skunk Works) said: 'Several of our aerodynamics experts including Dick Cantrell seriously thought that maybe we would do better trying to build an actual flying saucer. The shape itself was the ultimate in low-observability.' After making this intriguing statement, Rich went on to say, 'the problem was finding ways to make a saucer fly. Unlike our plates, it would have to be rotated and spun. But how? The Martians wouldn't tell us'. This was clearly an attempt on his part to dismiss the flying saucer as unworkable, which lends some weight to the belief that the development of prototypes with flying saucer characteristics has occasionally gone further than anyone is willing to admit.

In fact, Lockheed's Skunk Works were at the forefront of flying disc design during the early 1950s, with several interesting studies being overseen by their leading propulsion engineer Nathan Price. Under Price's direction, a team of engineers secretly developed plans for an impressive VTOL ramjet-powered flying saucer and work on this particular project was undertaken during a period of several years. In technical documentation, Price makes a very good case for the flying saucer. He notes that the bi-convex planform is a rigid strong structure that allows an even landing force distribution and provides maximum volumetric payload efficiency. He also talks about uniform distribution of thermal stress at high speed and simple inexpensive construction.

These postwar flying disc designs by leading defence contractors such as Lockheed have encouraged many conspiracy theorists to suggest that small numbers of disc and triangular-shaped aircraft were built for either the purpose of psychological warfare or to act as totally deniable, radar-invisible spyplanes, which have taken full advantage of the UFO factor. This kind of speculation raises questions that are well beyond the scope of this book, although it has been possible to build and fly circular winged aircraft for almost a century, despite early propulsion and aerodynamic difficulties.

One thing is certain, the disc-shaped aircraft has intrigued many of the most respected aeronautical designers of the 20th century. The first powered circular (or annular) winged aircraft were conceived by enthusiasts and inventors almost 100 years ago, and by the early 1950s teams of engineers working for the best known defence contractors were designing disc-shaped flying machines that would still look very advanced today.

This does rather beg the following questions: why are there no disc-shaped aircraft in civil or military service and why is the VTOL capability largely limited to helicopters? These are hard questions to answer, but equally surprising is the fact that there are no operational supersonic airliners, no single-stage-to-orbit spaceplanes and no lunar bases, which all seemed like cast-iron certainties for the present era. Having said that, it seems probable that increasing numbers of aircraft with strikingly unfamiliar designs will begin to fill our skies during the coming decades.

Not every aircraft featured in this book can be described as a true flying saucer. Vehicles examined range from VTOL spade and heel-shaped fighters to high-altitude balloons associated with UFOs, exotic 'ring wing' ducted fan designs and unusual proposals for spacecraft. Nevertheless, all of the projects described in this work are linked in various ways to the theme of *man-made* flying saucers. Hopefully, this book provides details of the more significant aircraft and space vehicles that have frequently been dismissed as fantasy and I am in no doubt that information on this fascinating subject will continue to surface during the coming years.

Bill Rose
Norfolk, England. 2006

Chapter One

Early Circular-Winged Aircraft

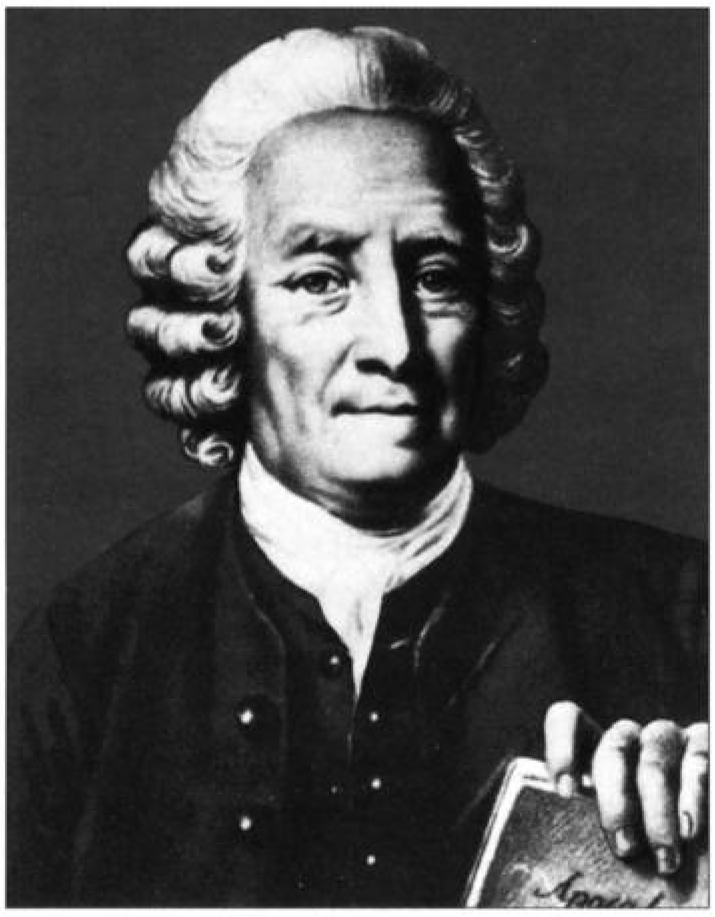
The elliptical or circular planform is widely perceived as a modern concept, but the first recorded proposal for a flying apparatus with this type of profile was produced by the 18th century Swedish scientist, theologian and philosopher Emanuel Swedenborg (1688-1772), who completed a detailed study in September 1714. Like many of Leonardo Da Vinci's similarly futuristic ideas, this concept was centuries ahead of its time but had many obvious flaws. Swedenborg intended to use flapping wings for propulsion, with flight control achieved by their manipulation. The design was oval-shaped, but he went on to discuss the possibility of circular and perhaps square planforms.

The proposal was carried by Sweden's first scientific journal, *Daedalus Hyperboreus, d*uring 1716. It reported that Swedenborg's aircraft would be constructed from wood, covered in sailcloth, and flown by one person. The oval-shaped apparatus would have dimensions of 32ft by 24ft (9.75m by 7.3m) and the circular version was to have a diameter of 25ft (7.62m). Swedenborg suggested that the flying machine should be built and tested in model form first, but his outlandish project never progressed any further and the idea had soon been forgotten by almost everyone.

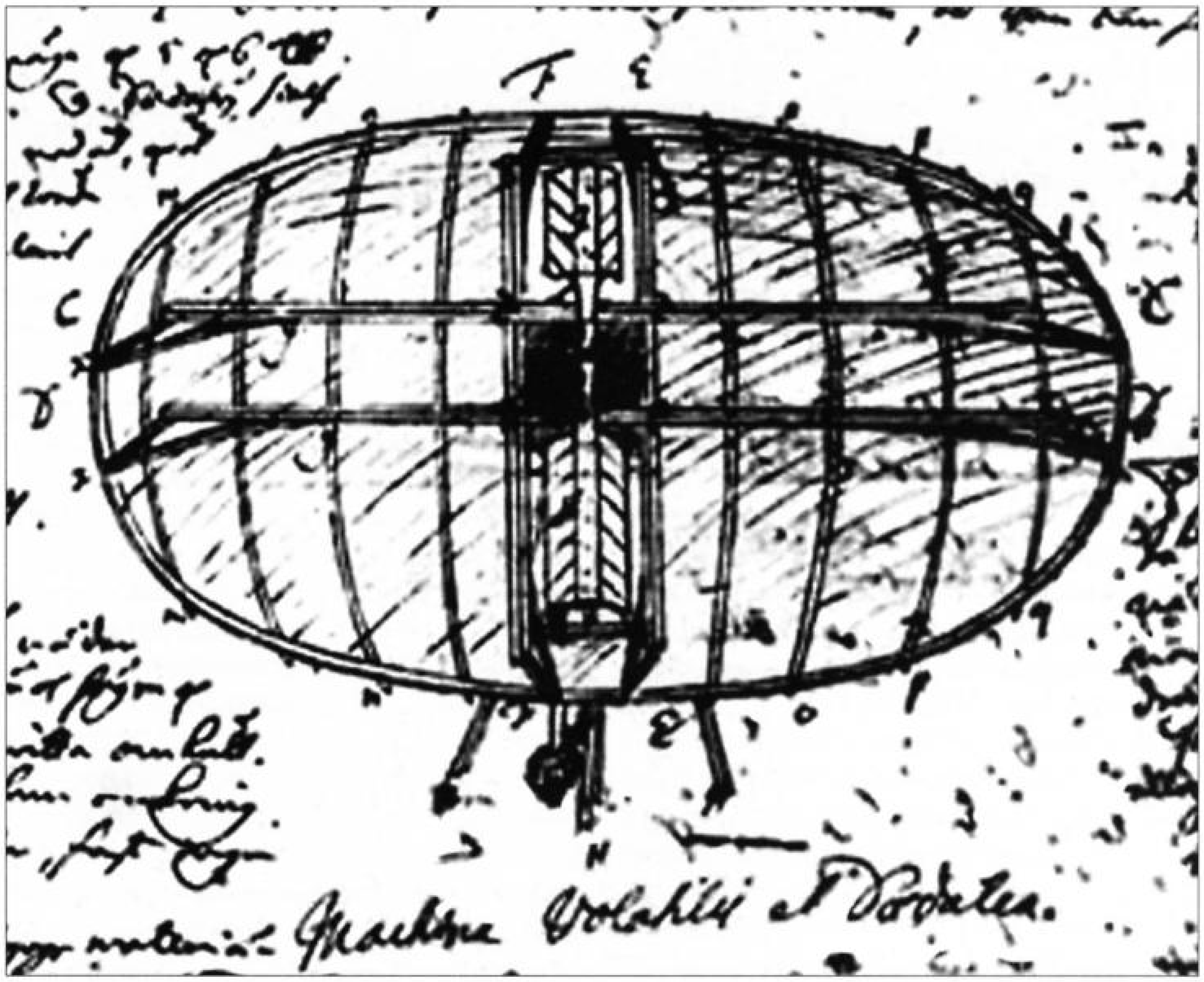
155 years later, a French inventor called Alphonse Pénaud (1850-1880) completed a small model aircraft with a length of 20in (508mm) and a wingspan of 18in (457mm). It was powered by a rubber band that turned a rear-mounted 8in (200mm) propeller. Pénaud called this tiny monoplane the Planaphore. On 18th August 1871 he flew his model at the Tuileries Gardens in Paris and the Planaphore covered a distance of 131ft (40m) in eleven seconds, in the process proving to be very stable in flight.

The success of this experiment encouraged Pénaud to build a small rubber band-powered helicopter using contra-rotating propellers and he then designed a number of astonishingly advanced aircraft that included an elliptically shaped seaplane driven by two steam-powered propellers. His ideas were years ahead of their time and in 1875 they won him an award from the French Academy of Sciences. By 1876 Pénaud had teamed up with an engineer called Paul Gauchot and they designed and patented a full-sized aircraft, anticipating the development of a lightweight steam engine with sufficient power to provide their machine with a level flight speed of about 60mph (96km/h). Based on Pénaud's earlier concept for a seaplane, the two-man elliptical Pénaud-Gauchot aircraft incorporated many radical innovations such as a glass-covered cockpit, a retractable tricycle undercarriage and a modern control stick. In 1880 Pénaud approached the airship pioneer Henri Giffard seeking support for the design, but Pénaud met with total rejection and, as a consequence, he committed suicide.

Towards the end of the 19th century there were a number of inventors experimenting with circular and elliptical platforms suspended beneath balloons, or building gliders

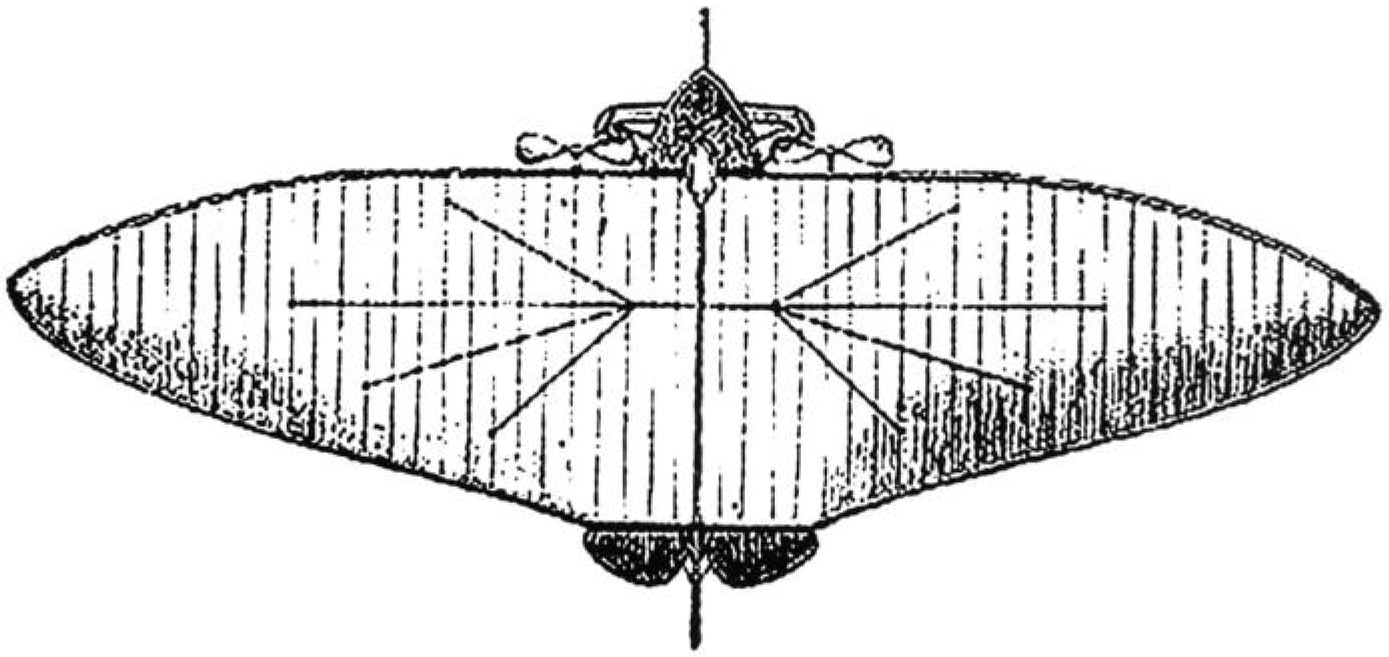


Emanuel Swedenborg – the 18th century Swedish scientist, philosopher and mystic, who designed an oval-shaped flying machine in 1714. Bill Rose Collection

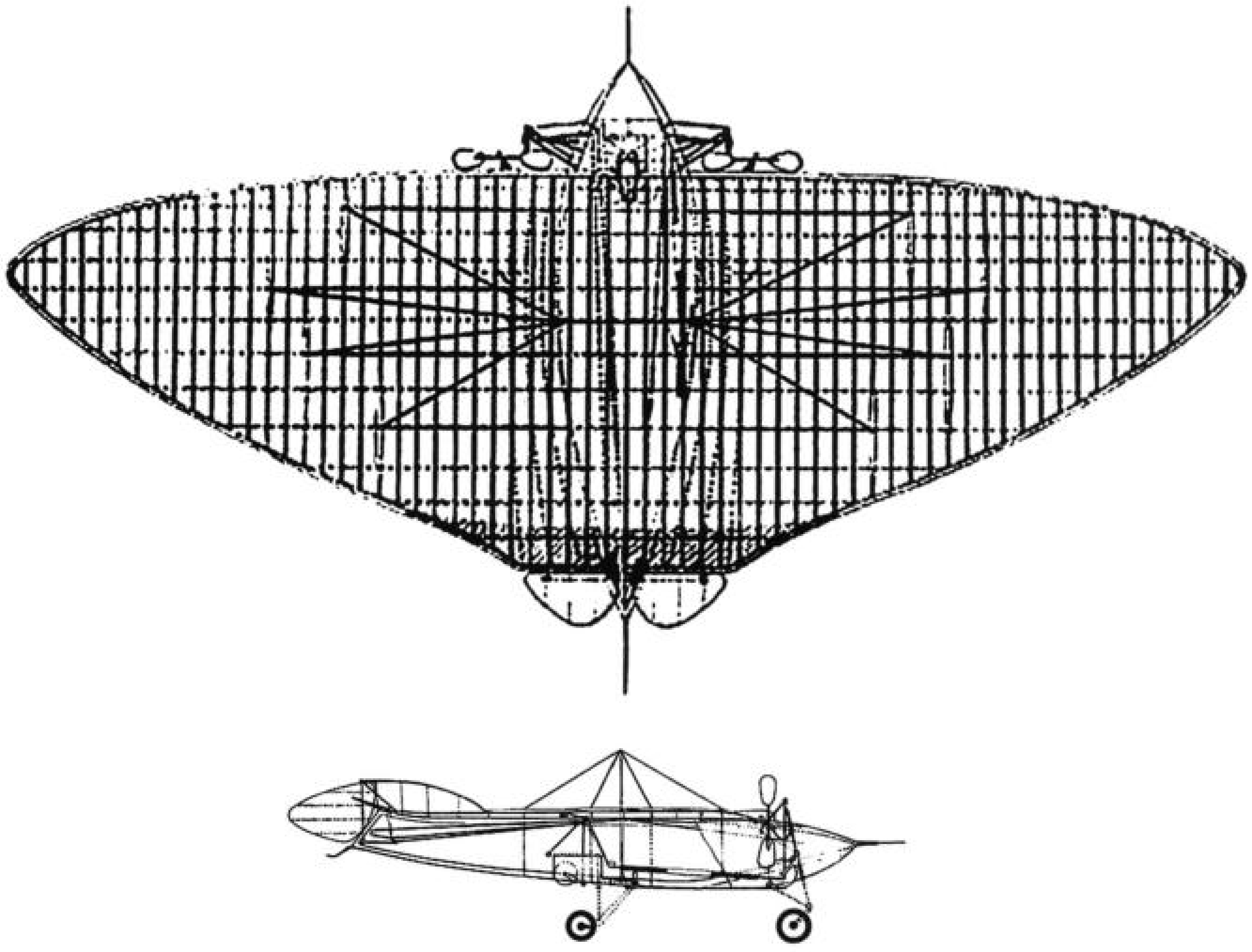


Swedenborg's Flying Machine 1714, as originally shown in his notes of 1714. Bill Rose Collection

Born in Paris, Alphonse Pénaud (1850-1880) took up aeronautical design after he failed a medical examination for the French Navy due to a hip problem. He then turned his attention to the design of a heavier-than-air powered craft. Although he never progressed beyond the construction of models, Pénaud was decades ahead of his time, producing a number of revolutionary innovations that would become accepted when powered flight was achieved. via Bill Rose

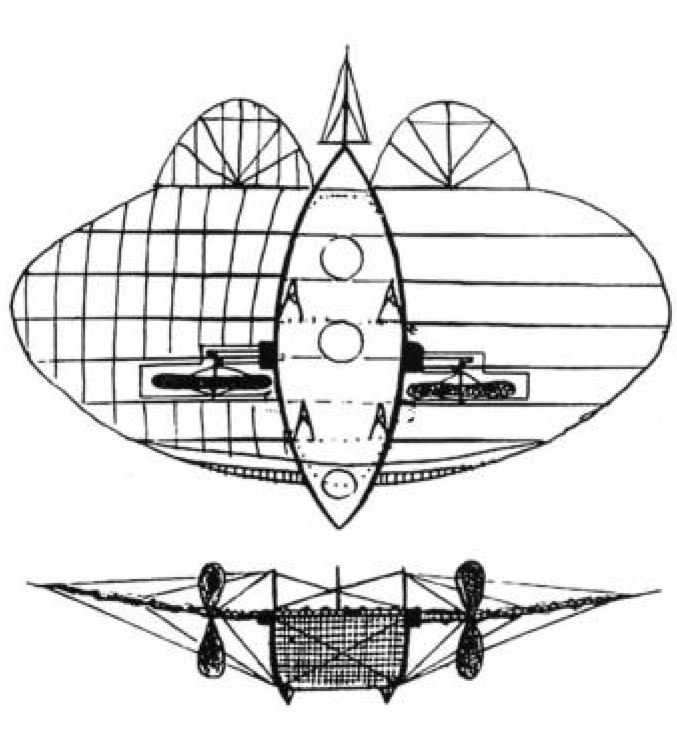


Pénaud design for an elliptical aircraft. via Bill Rose



Above: **Pénaud-Gauchot 1876 design for an elliptically shaped steam-powered aircraft.** via Bill Rose

Right: **Pénaud's 1873 design for a steam-powered, twin-propeller seaplane.** via Bill Rose

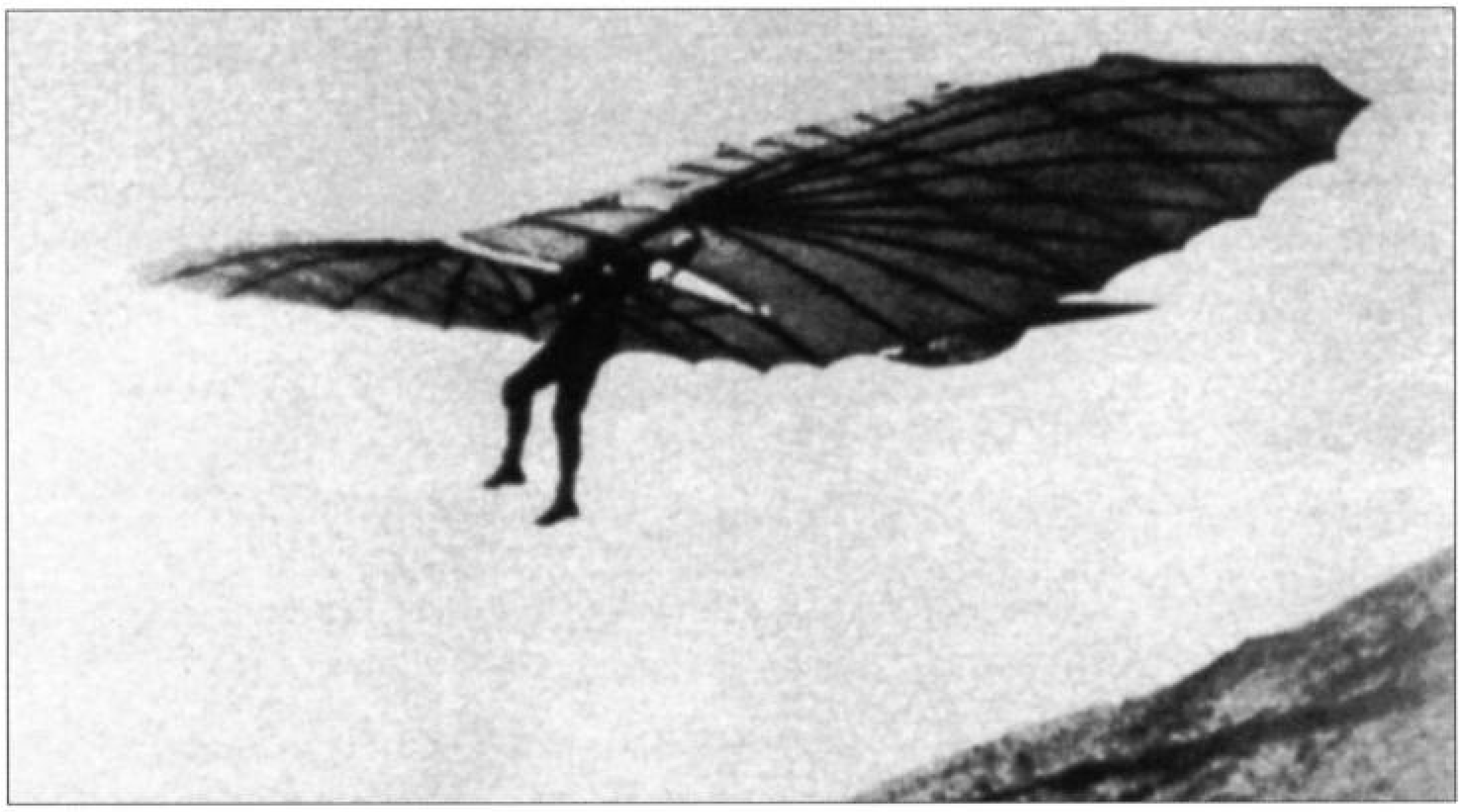


with unusual wing shapes. One of these pioneers was the German inventor Otto Lilienthal (1848-1896). He began to fly manned gliders in 1891, using various configurations that would encourage the development of flying wings and circular-shaped aircraft. He conclusively demonstrated that heavier-than-air flight was possible without flapping wings and his work proved highly influential. However, Lilienthal suffered an increasing number of accidents and died on 10th August 1896 after crashing a glider during the previous day.

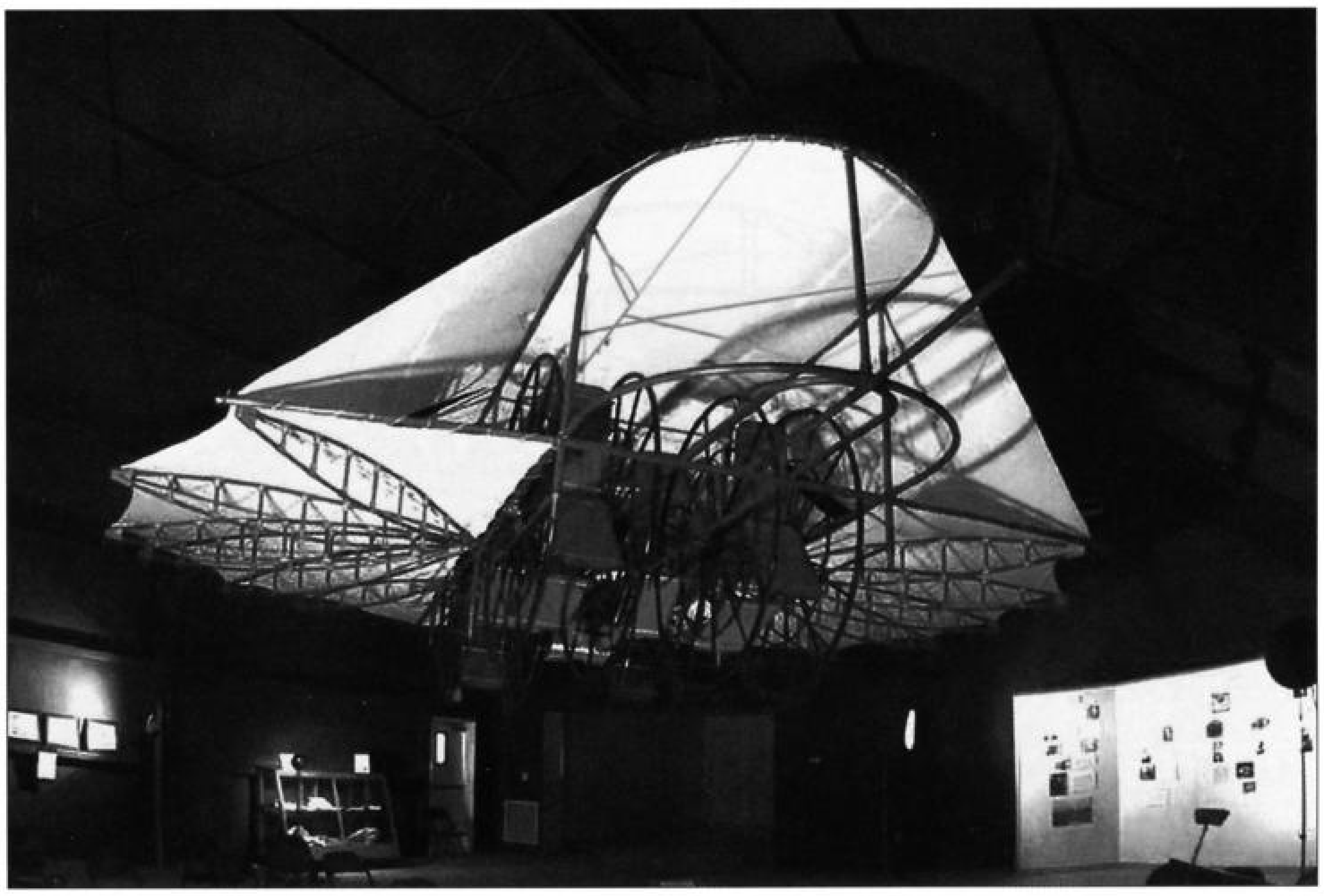
Lilienthal was followed by the Rev Burrell Cannon (1848-1922), an American Baptist pastor and skilled engineer, who began to work on the design of a powered flying machine in 1898. His plans were completed by August 1901 and the Reverend raised enough money from various friends to ensure that the aircraft was built. Called *Ezekiel*, this flying machine was semi-elliptical in shape and had a span of 26ft (7.92m). It was constructed from wood, covered in canvas, and powered by a small 40hp (29.8kW) internal combustion engine driving a series of wheels fitted with paddles, which acted as propellers.

The aircraft was built at P W Thorsell's foundry in Pittsburg, Texas, with most of the work being carried out by an engineer who worked for Thorsell called Gus Stamps. Once completed, *Ezekiel* was moved to a field not far from the factory and test flown by Stamps on an unspecified date in late 1902. It was reported that *Ezekiel* flew for a distance of at least 160ft (48m) at a height of about 12ft (3.65m), but the flight was not documented and even Cannon was elsewhere at the time. Witnesses to the event insisted that Stamps had piloted the aircraft across a fence into an

Above: **Otto Lilienthal, the German glider pioneer of the late 19th century.** via Bill Rose



Above right: **Otto Lilienthal undertakes a glider test. Exact date unknown.** via Bill Rose



A replica of the Ezekiel flying machine at the Northeast Texas Rural Heritage Museum in Pittsburg, Texas. Northeast Texas Rural Heritage Museum

adjoining pasture and, by rights, this should have been recorded as the world's first powered flight. However, *Ezekiel* was damaged when Stamps made a hard landing and there were insufficient funds available to effect immediate repairs.

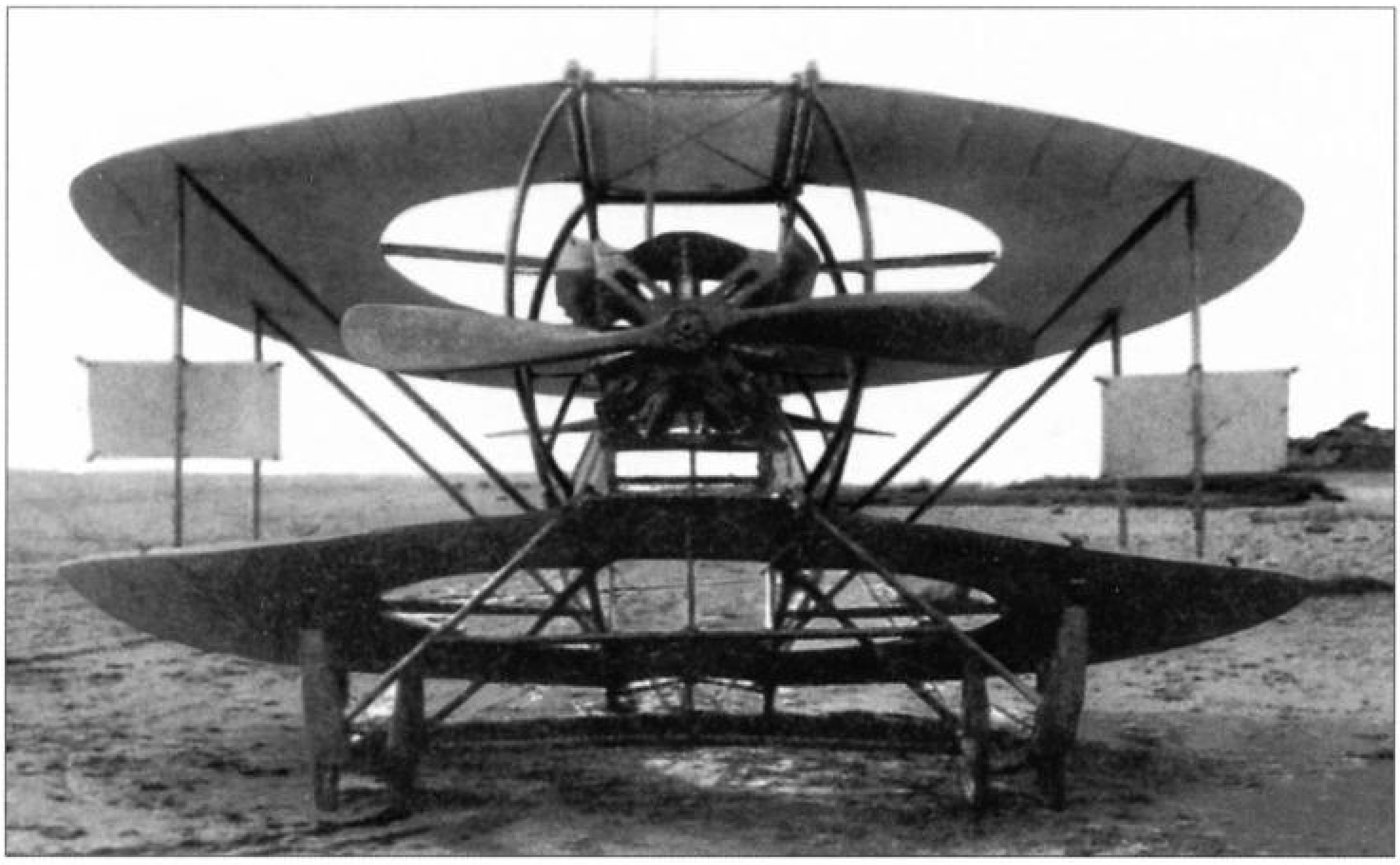
In early 1903, Cannon agreed to have the aircraft shipped by rail to Texarkana, Texas in an attempt to drum up publicity. The undercarriage had been fixed and another flight would be undertaken there. Depending on the outcome, *Ezekiel* would then be moved to St Louis for the World Fair, which had originally been scheduled to open in late 1903 (but was finally postponed until 30th April 1904). However, events never progressed this far. While *Ezekiel* was being shipped by train to Texarkana, a severe storm blew the aircraft from the freight platform and it was completely destroyed. Details of *Ezekiel* and its historic flight soon faded into obscurity, although a Texan engineer called Bob Loughery built an exact replica of the aircraft in 1986. This can now be seen at the Northeast Texas Rural Heritage Museum in Pittsburg, Texas.

On the 17th December 1903, Orville Wright undertook a twelve-second flight at Kitty Hawk, North Carolina and covered a distance of 120ft (36.5m), thus assuring him and his brother Wilbur a place in the aviation hall of fame. With the arrival of propeller-driven aircraft, this quickly led to the design of circular wings that attempted to provide stability and maximum lift without the penalty of a substantial span.

One of the first constructors to build an aircraft using this wing shape was Captain Joseph Donovan, who prepared his machine for testing at West Hartlepool, England in October 1909. Louis Blériot had crossed the English Channel on 25th July, the Wright Brothers were touring Europe, and there was now considerable interest in building the first truly commercial aircraft. Donovan hoped that his unusual-looking machine might be good enough to secure a slice of this developing market and he invested a great deal of time, effort and money into the project.

The aircraft had a span of 28ft (8.5m) and it was powered by a Fothergill 30hp (22kW) six-cylinder engine driving a pair of two-blade pusher propellers, with two vertical propellers fitted for lift. Hopelessly overweight at 1,000 lb (454kg), totally underpowered and rather poorly conceived, Donovan's aircraft was barely able to move along ground under engine power and he finally abandoned the idea.

The following year John George Aulsebrook Kitchen, who was an engineer and inventor living in Scotfort, Lancashire, built a biplane with annular wings. Most parts of the aircraft were exposed to the elements, with his design taking the form of a simple open framework and wings. Propulsion was pro-



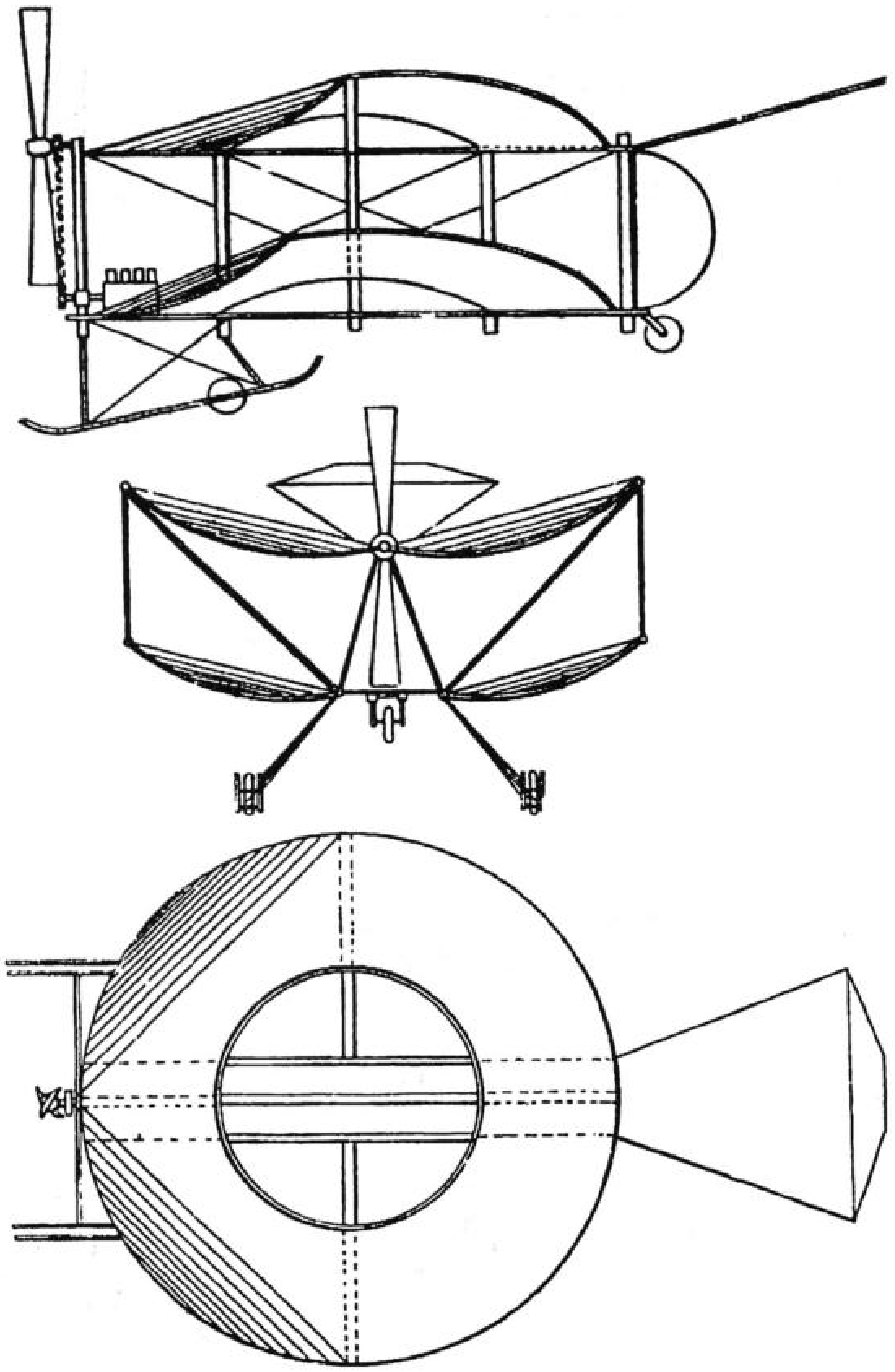
John Kitchen's annular-winged biplane at Middleton Sands, circa 1911. via Bill Rose

vided by a small forward-mounted internal combustion engine driving a two-blade wooden propeller and the pilot sat immediately behind the motor. The undercarriage was formed from twin skids with two pairs of what look like pram wheels at the front and small runners at the rear of the aircraft. Construction was almost entirely from wood, with fabric covering each wing. The machine appears to have been rather delicate and susceptible to damage.

Kitchen soon lost interest in the idea of trying to make his aeroplane fly and it was stored away in a large shed at Middleton Sands, near Heysham, Lancashire. The aircraft was then sold to Cedric Lee, a wealthy weaver, who brought in his friend George Tilgham Richards (who was an engineer and designer) to assist. Lee and Richards completed work on the aircraft in mid-1911 and it was test flown on several occasions as a glider. Piloted by Cedric Lee, the biplane is said to have been very stable, although Richards made ongoing modifications to the leading edge while trials continued. However, the aircraft was damaged during a rough landing and finally destroyed when the storage shed at Middleton Sands collapsed during a strong gale in November 1911.

Before building a replacement aircraft, Lee and Richards decided to complete two small model gliders and experiment further with alterations to the leading edge camber. Each model had a span of 4ft 7¾in (1.42m) and most flights were conducted inside a hangar. They soon discovered that extra camber produced a flatter glide angle, which encouraged them to build a second one-man biplane glider. This was finished in 1912 and featured an upper annular wing with a diameter of 22ft (6.7m) and a wing area of 400ft^2 (37.17m^2). Additional control surfaces were added as testing progressed. The initial empty weight for the second Lee-Richards aircraft was 215 lb (97.5kg), which rose to 710 lb (322kg) with the pilot and some ballast.

Test flights were mainly conducted by Lee at Sellet Banks, alongside the River Lune between Whittington and Kirkby Lonsdale. The glider was launched using a catapult and track arrangement that used a large weight within a tripod frame. The aircraft proved to be very stable in flight and fairly easy to con-

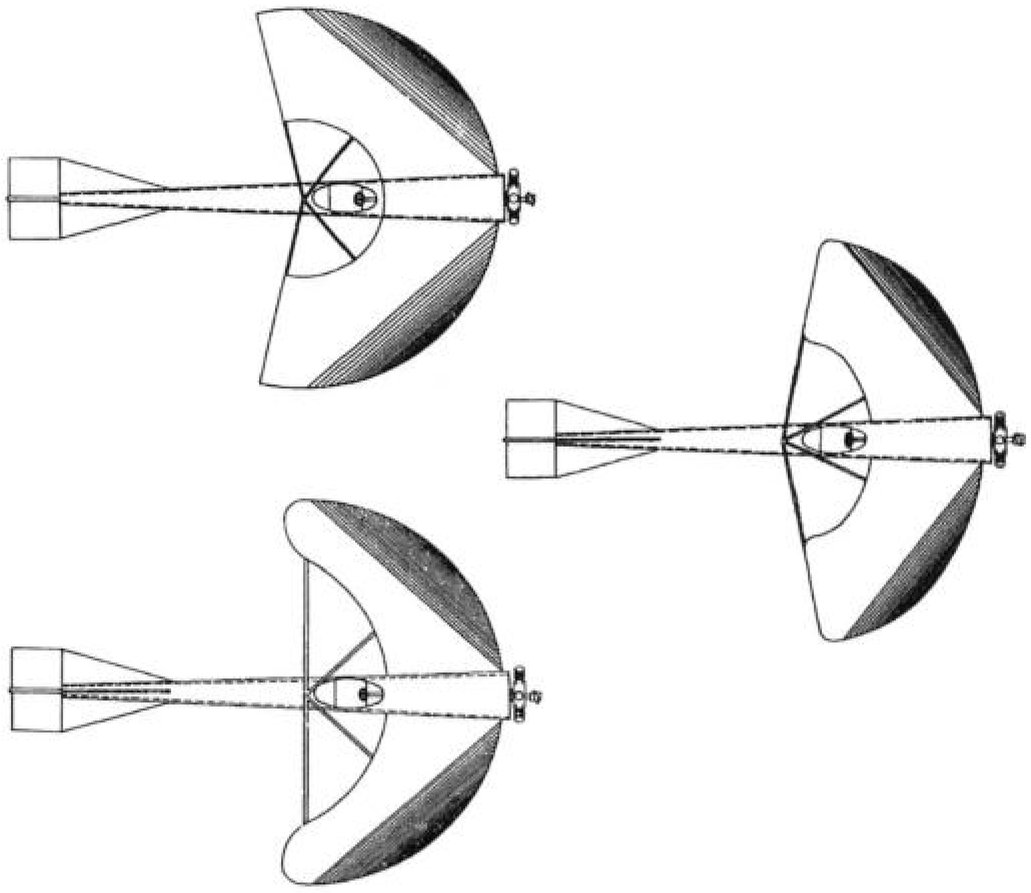


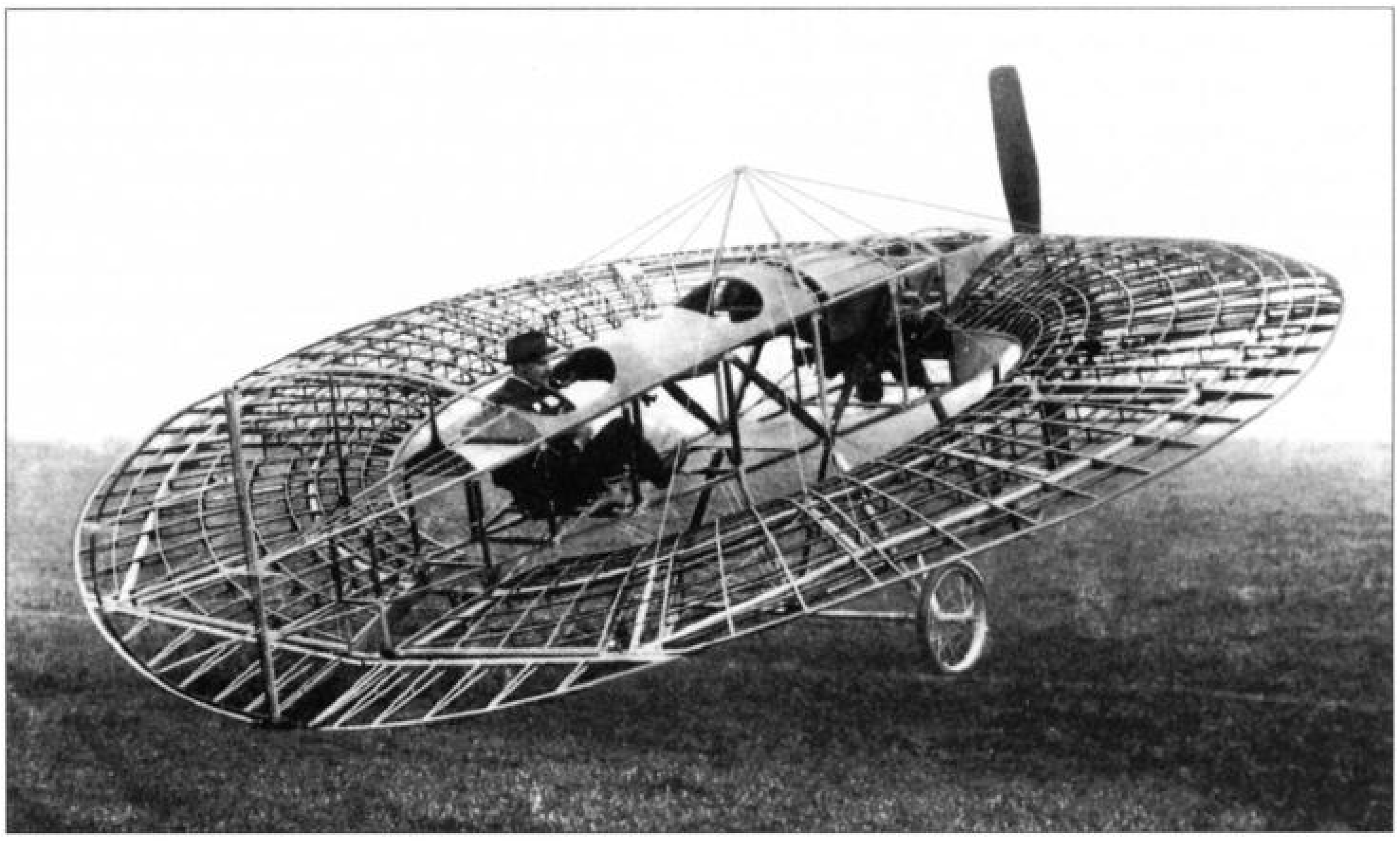
One of John Kitchen's pre-World War One circular-wing aircraft designs. via Bill Rose

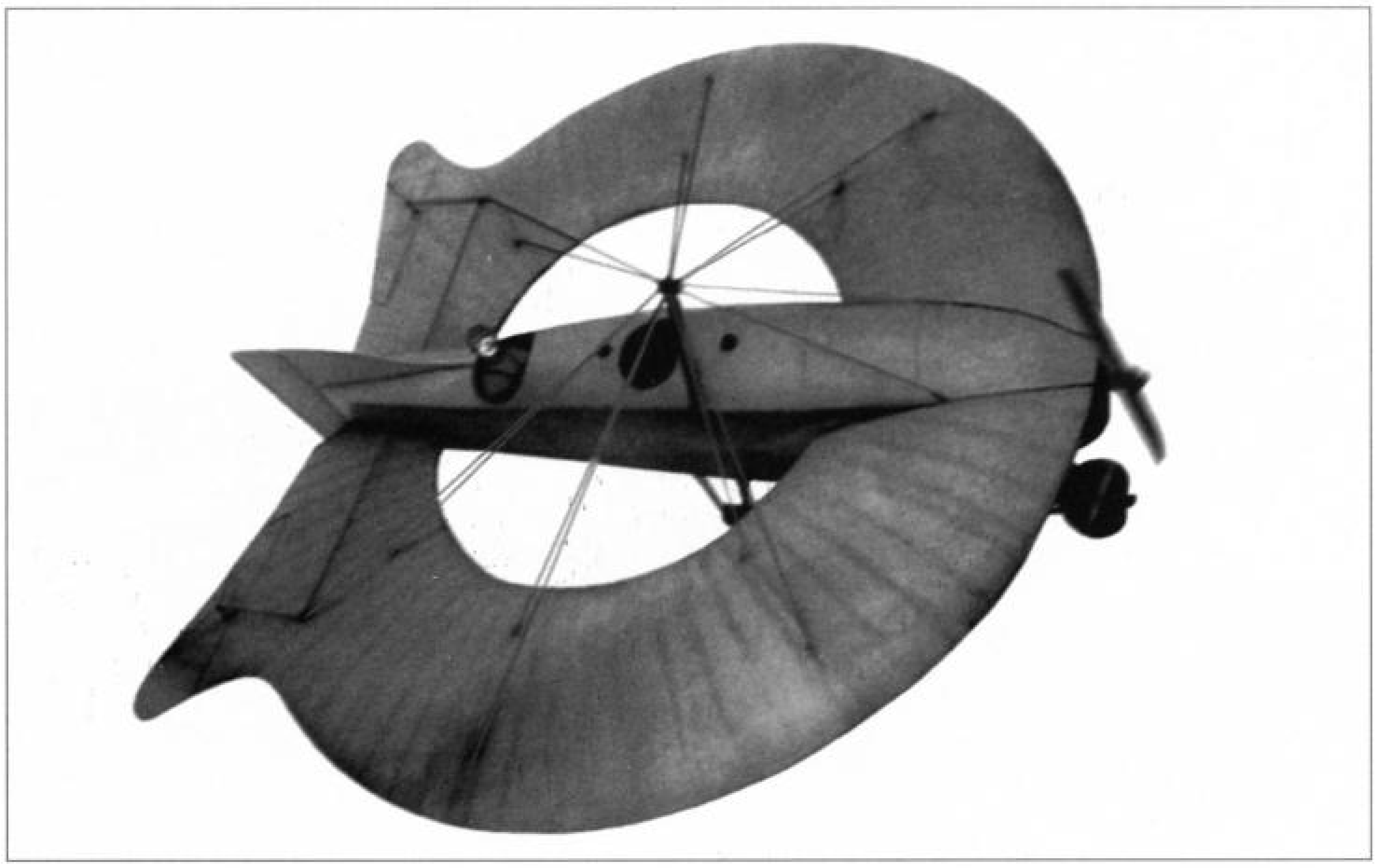
A series of pre-World War One wing designs produced by John Kitchen. via Bill Rose

The original Lee-Richards circular-winged monoplane prior to completion. via Bill Rose

Lee-Richards circular-winged monoplane in flight. This is believed to be the second version of this aircraft. via Bill Rose







trol. Lee made numerous flights from February 1912 onwards and the trials were finally concluded in December. Some film footage showing Lee making one of these flights appears at the beginning of Ken Annakin's 1965 movie *Those Magnificent Men in their Flying Machines* and a moderately accurate non-flying replica of Kitchen's aircraft was also used in this production. Recently renovated, it can now be seen at the Shoreham Airport Archive & Visitor Centre, West Sussex.

Kitchen retained an interest in Lee and Richards' flying activities, possibly offering them technical support. He also applied for a number of aircraft patents during this period, which included various circular and parabola-shaped wing designs. In January 1913, Lee and Richards moved down to London and hired an engineer by the name of James Radley, and his assistant Eric England, to build a new aircraft for them at Shoreham Aerodrome in Sussex.

Their first design was a propeller-driven annular-wing monoplane, which took full advantage of all the preceding research and development. The appearance of this aircraft differed considerably from the earlier designs. The fuselage was enclosed with fabric and the pilot sat near the centre of the wing, which was braced with wire cables from an upright support. Completed by the end of 1913 at Shoreham, it demonstrated exceptional lift and was flown around a 5-mile (8-km) circuit by England. However, on his return to the airfield the 80hp (59.6kW) Gnome Lambda engine cut out as England made his landing approach and he crashed. England was unharmed, but the aircraft was a write-off.

Some parts were salvaged from the wreckage and construction of a second monoplane began in early 1914. The original design was further modified with additional elevators and a tricycle undercarriage fitted. In March 1914 England flew the aircraft, which apparently suffered from fairly bad yaw problems. Gordon Bell replaced England as the test pilot and further modifications were made to the control surfaces as trials continued. However, Bell lost control of the aircraft during a test flight in late April 1914 and crash-landed. He escaped with minor injuries, but the monoplane was severely damaged.

A third aircraft was built with yet more refinements and it performed well. Most of the earlier problems were eliminated and Bell continued to fly the aircraft up to the beginning of World War One. He was then called up to serve in the Royal Flying Corps so Lee took over as the test pilot. Unfortunately, Lee managed to crash this aircraft into the River Adur near Shoreham Aerodrome and it spelt the end of his attempts to create a new type of aircraft with commercial potential.

The Umbrellaplane

In January 1911, Harold McCormick and William Romme completed a small experimental aircraft at Belmont Park, New York. The appearance of this design was quite striking, with a framework supporting fabric-covered 'reverse parasol' wings, braced by wires from a central steel pillar. Because of the unusual shape it was called 'The Umbrellaplane', although it also earned the name 'Mustard Plaster' because of its yellow-pigmented fabric covering. A small French-built 50hp (37kW) Gnome 7-cylinder rotary engine was located towards the centre of the aircraft and drove a two-bladed wooden pusher propeller via a long shaft behind the wings. The pilot sat at the front of the engine, just behind the wing's leading edge. The wing had a diameter of about 35ft (10.6m). Gross weight of the aircraft is unknown, but it would be regarded as fairly light.

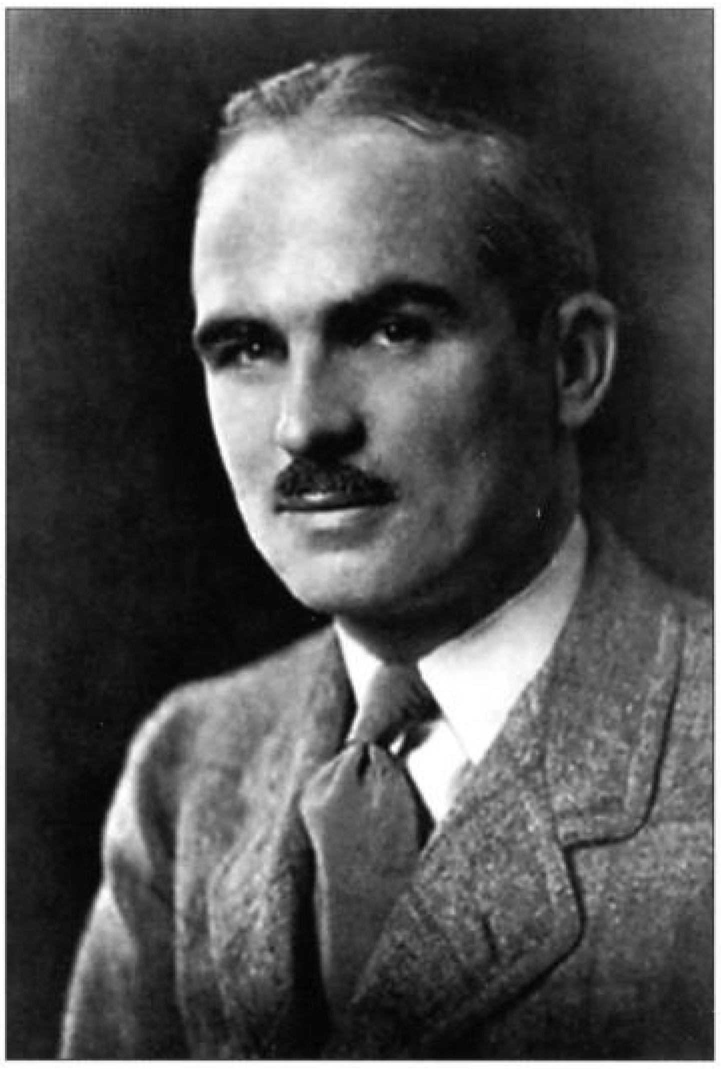
Assisting McCormick and Romme was Chauncey 'Chance' Milton Vought (1890-1930), a talented engineer from Long Island, New York, who also had a pilot's certificate and would later become a major player in the US aviation industry. Another involved in the project was Andrew Drew, a well-known pilot of the time. Endorsing the suggestion that development of the Umbrellaplane seems to have been something of a hobby for this group of wealthy young men, the financial backing was provided by William Rockefeller Jnr.

The Umbrellaplane had yet to fly and, in April 1911, a decision was taken to relocate to San Antonio, Texas, where the weather was rather more agreeable. The aircraft was disassembled, shipped across the country and finally prepared for flight, but during a taxying trial it flipped over on some rough ground and was seriously damaged. Then a decision was made to undertake a rebuild at the Aero Club of Illinois' new airfield at Cicero, Chicago, primarily because there was insufficient engineering support available in the San Antonio area.

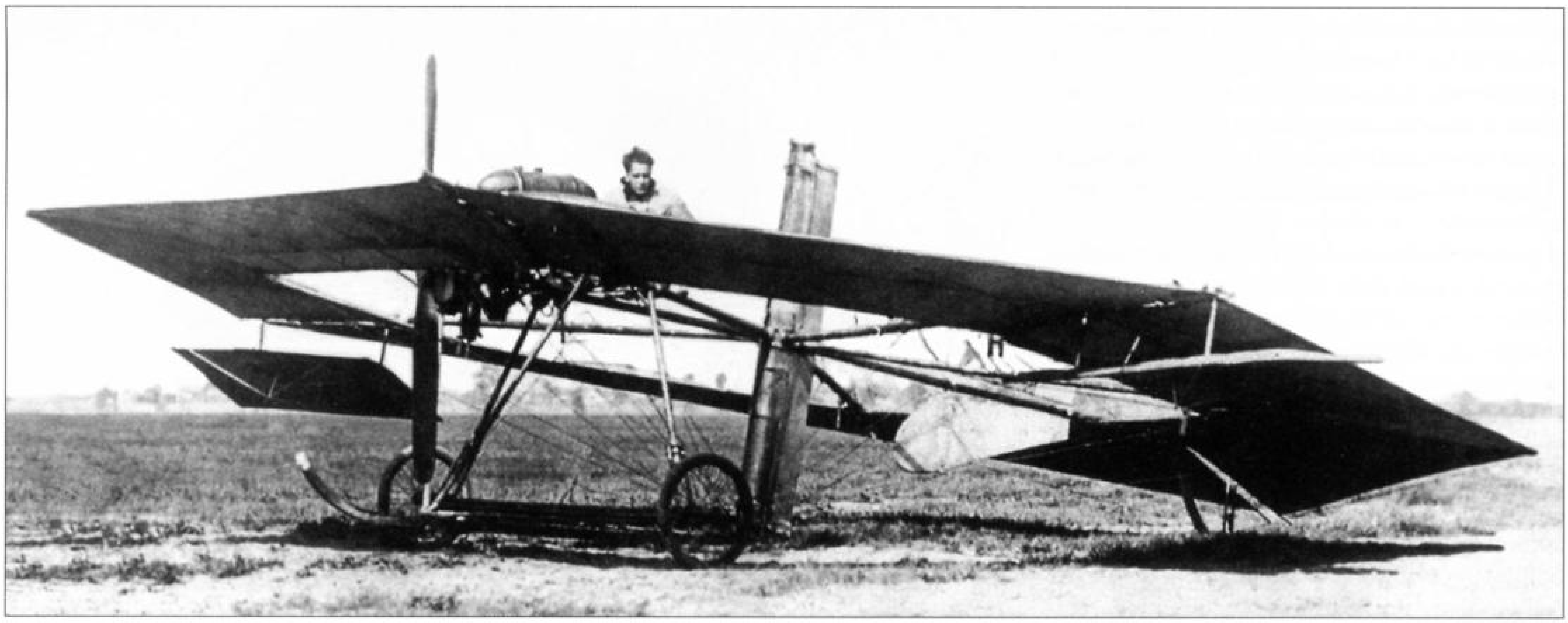
Working under Vought's direction, construction of what amounted to a new Umbrellaplane began at Chicago. Additional control surfaces were added and there were some modifications to the internal layout that moved the pilot rearward but retained the same centre of gravity. Nevertheless, there were still some serious problems with the design that were not helped by inadequate engine performance, and when trials commenced the aircraft refused to leave the ground.

Vought made further modifications to the wings and, in April 1912, André Ruel managed to fly the Umbrellaplane for a very brief distance. More short flights followed and Vought continued to make changes to the design. After this, the Umbrellaplane was grounded during the winter, with trials resuming in March 1913.

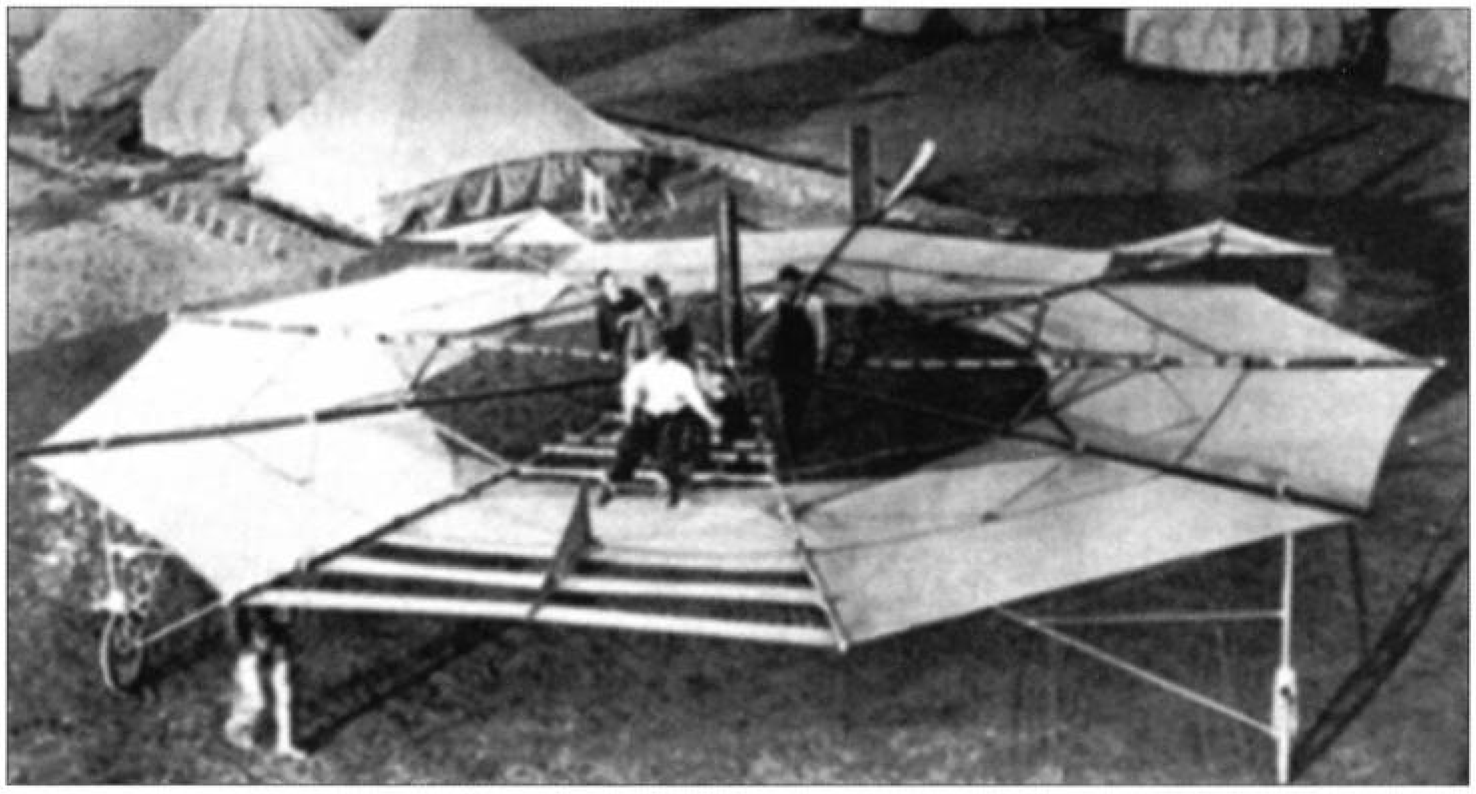
By now, the aircraft had undergone at least seven major revisions or complete re-builds, with numerous different features being tried. This included many alterations to the control surfaces, changes to the undercarriage and the use of various engines, with the Umbrellaplane being configured as a tractor and pusher design. Although the Umbrellaplane



Chance Vought, the engineer who assisted McCormick and Romme with development of the Umbrellaplane. Vought would later become a major player in the US aviation industry. Vought Aviation



Harold F McCormick and William S Romme's Umbrellaplane, showing its fabric-covered reverse parasol wings and distinctive shape. via Bill Rose



The Umbrellaplane is prepared for a flight attempt, exact date unknown. via Bill Rose

flew with difficulty several times during 1913, it was not a success and the project was finally abandoned towards the end of the year. The fate of this aircraft is unknown, but it was probably scrapped.

Arup Inc

In 1930 Dr Cloyd Snyder filed a patent for a promising aircraft design and, with the help of Raoul Hoffman, established a small aviation company called Arup Inc at South Bend in Northern Indiana. Snyder made up the name of his company from the words 'air' and 'up', which described their intent quite well. He hoped to introduce an aircraft that would be the equivalent of the Model T Ford automobile and make flight accessible to the middle classes. Despite the Great Depression that followed the Wall Street Crash of 1929, Snyder still hoped that his concept would become a successful commercial product.

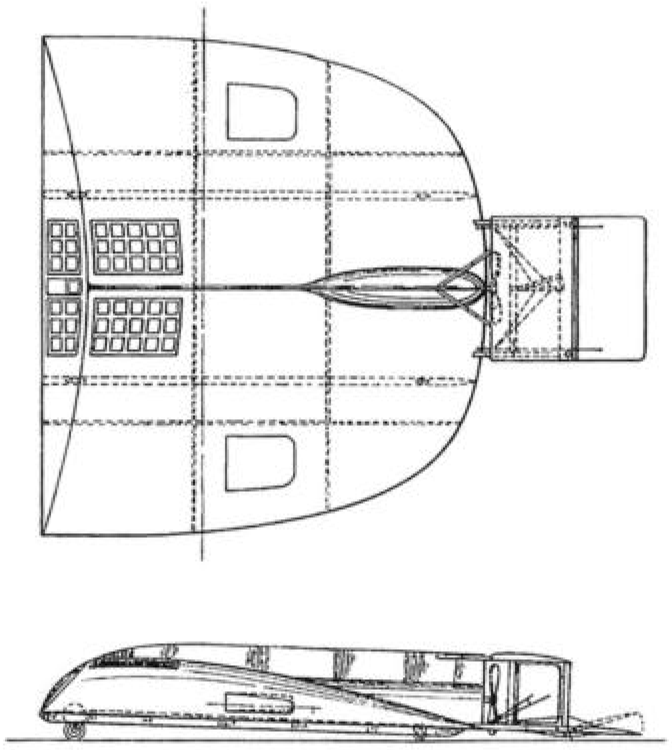
Arup Inc began construction of a small heel-shaped aircraft called Arup 1 although it is often referred to as the Dirigiplane, possibly because it was intended to contain a lifting gas. This was an extremely basic wooden glider that used wingtip ailerons and had no cockpit canopy or even a windshield to protect the pilot, who sat in the centre of the aircraft.

Testing began in 1932 and about 40 flights were completed, which proved the STOL concept to be valid. It was eventually decided to install a small Heath-Henderson internal combustion engine, although this modification was apparently not very successful. Snyder and Hoffman then progressed to construction of the Arup 2 (or Arup-Snyder 2), which was completed in 1933.

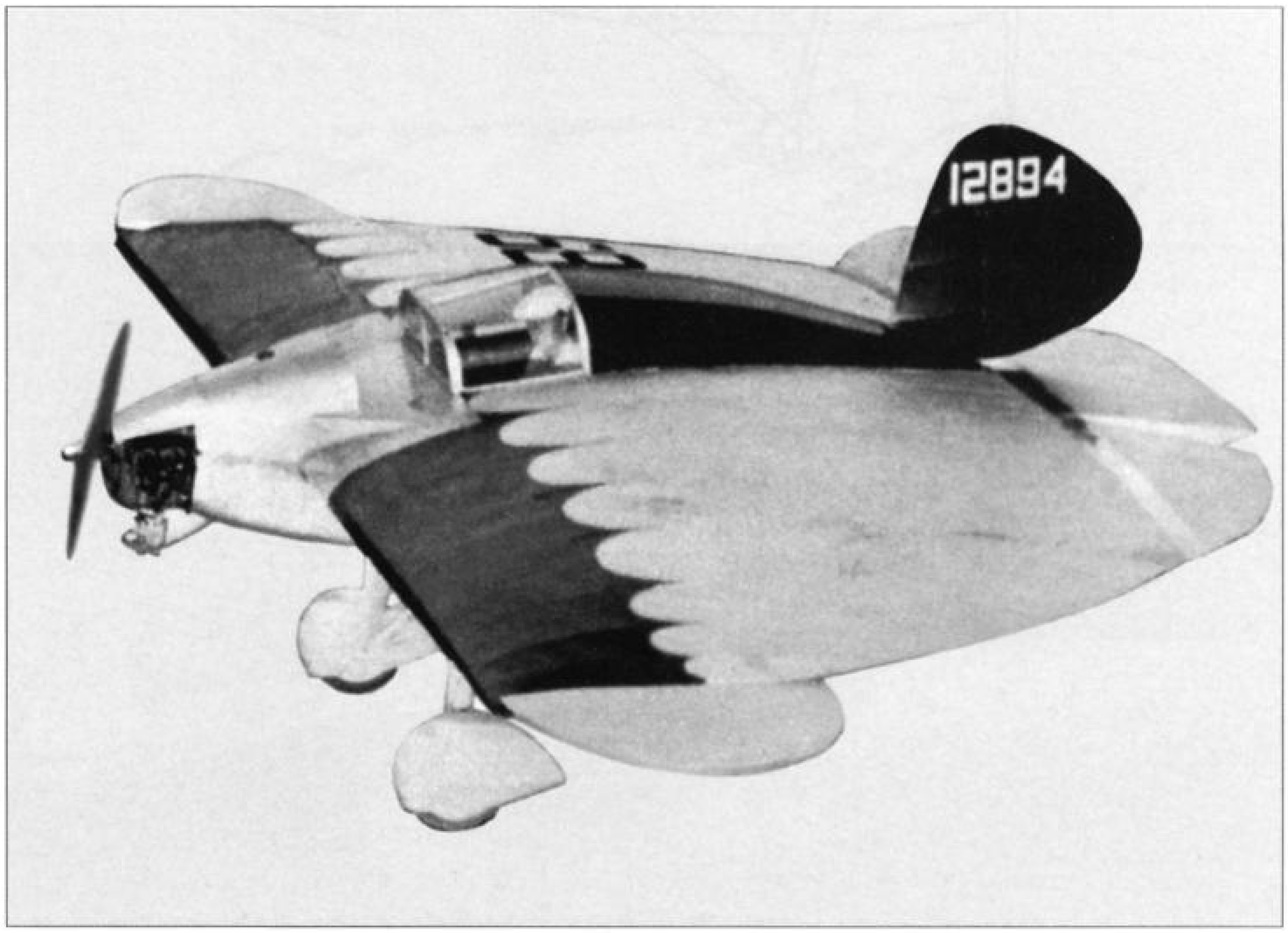
The Arup S-2 was altogether much more sophisticated than its predecessor with a proper enclosed cockpit and a 36hp (26.8kW) Continental A-40 engine for propulsion. The aircraft's dimensions were 19ft (5.8m) span and a length of 17ft 1¼ in (5.2m). Gross weight is believed to have been 780 lb (354kg) and maximum speed in level flight was about 97mph (156km/h). Wingtip ailerons were added and appear to have been repositioned as trials continued. Snyder flew the aircraft on a number of occasions, as did James Doolittle, and it was also loaned to NACA (National Advisory Committee on Aeronautics – the forerunner of NASA), who briefly tested it at Langley.

In 1934, the Arup S-3 was built and completed. This was essentially a slightly larger version of the Arup S-2 having a span of 22ft (6.7m) and a length of 17ft 6in (5.33m). A 70hp (52kW) LeBlond 5DE engine was fitted and the ailerons were positioned flush with the wingtips. The Arup S-3 completed one test flight and was then destroyed in a fire that was thought to have been arson.

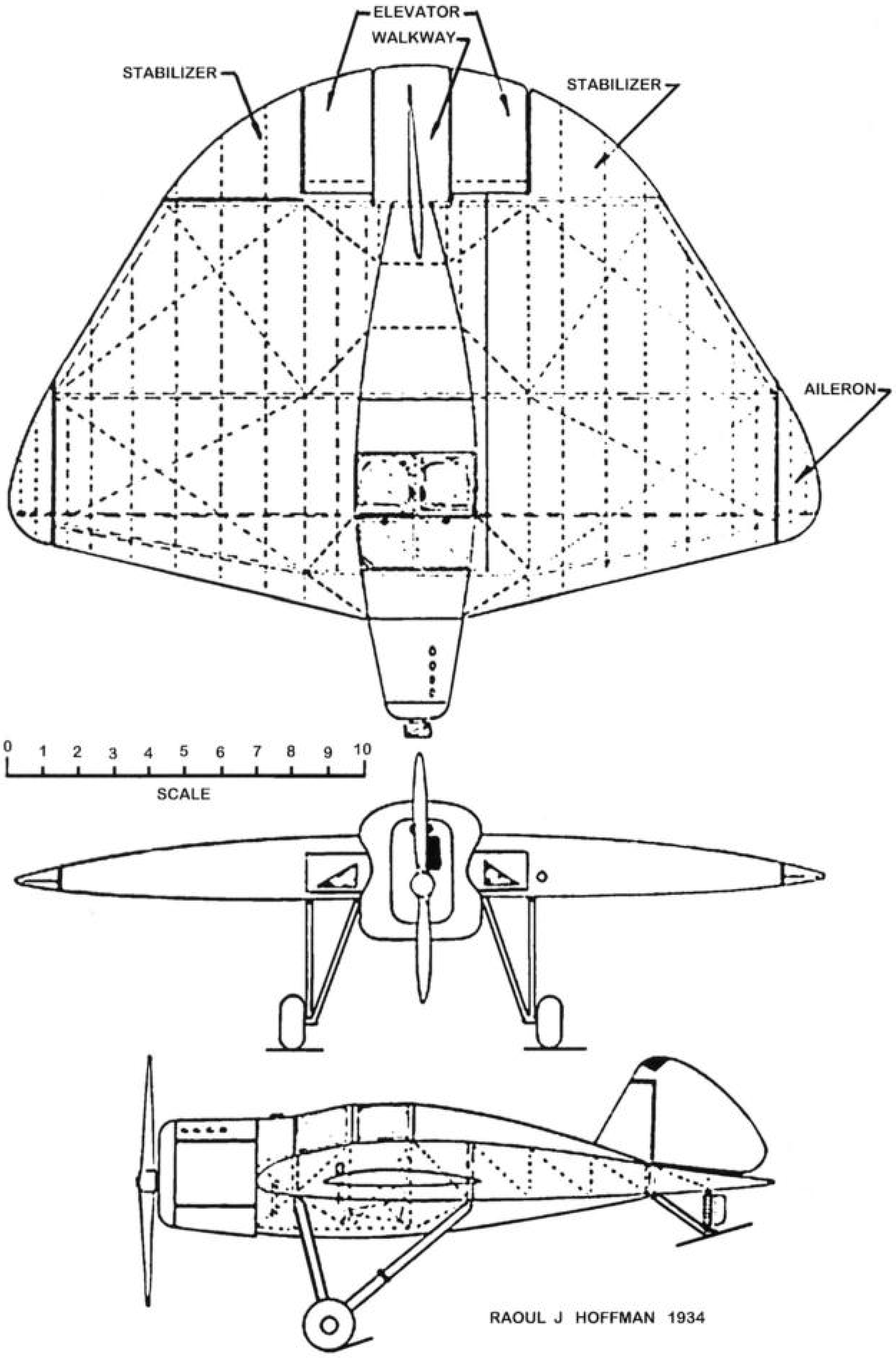
Also during 1934, Hoffman built a comparable aircraft for J Leslie Youngblood of Chicago, with dimensions similar to the Arup



Above right: **US Patent 1,855,695 filed in 1930 by Cloyd Snyder, which shows design features used in the first Arup wooden glider that began testing in 1932 and completed about 40 flights. A small Heath-Henderson internal combustion engine was fitted in 1932.** via Bill Rose



Right: **Arup S-2 in flight during 1934.** NASA archives / Bill Rose



Hoffman monoplane built for J Leslie Youngblood of Chicago in 1934. It was similar in many respects to the Arup S-2. via Bill Rose

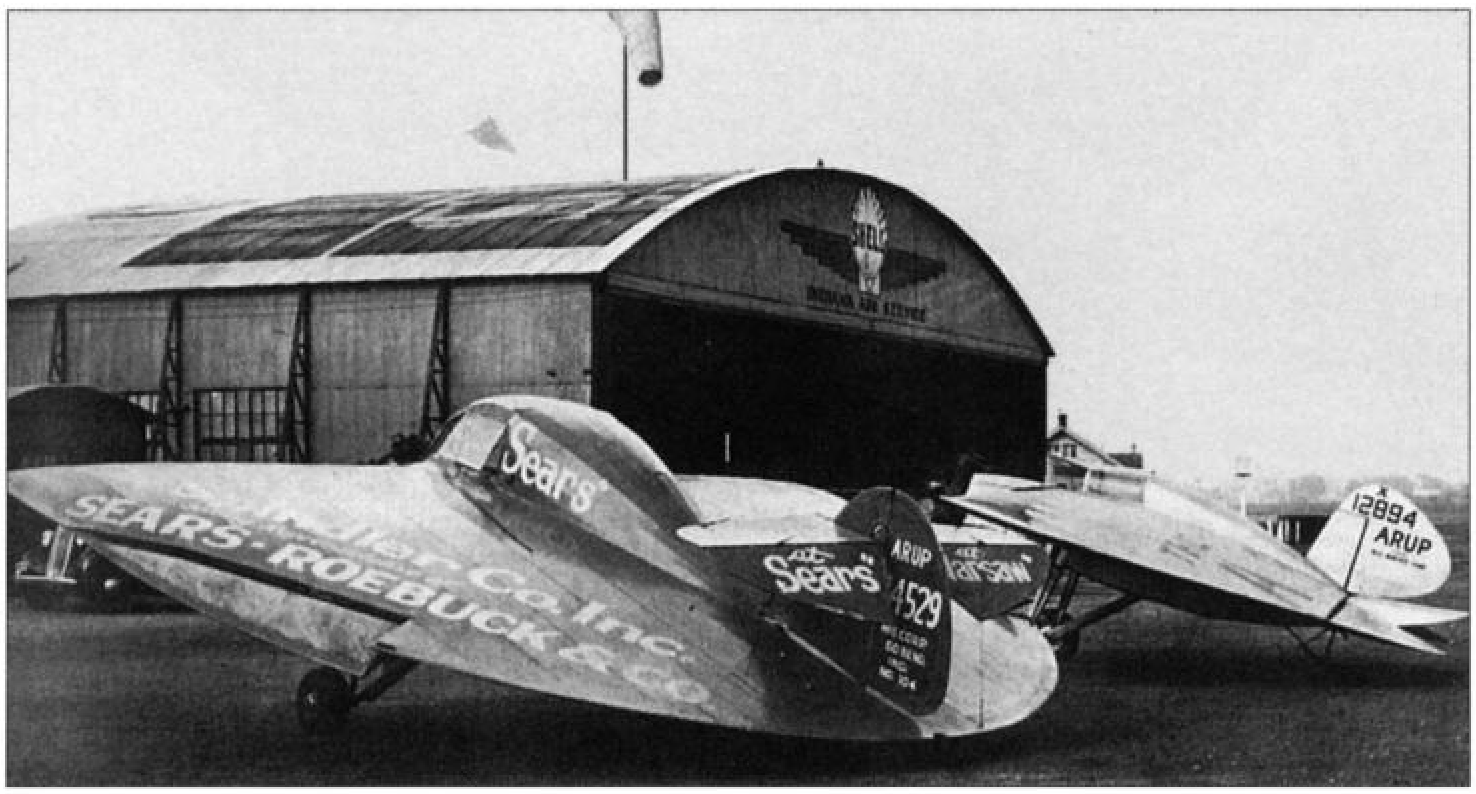
S-2. It was fitted with an 85hp (63kW) Cirrus Mk 111 engine and Hoffman planned to fit a fully retractable undercarriage, although this was never installed. During a flight in 1936 this aircraft caught fire and crashed.

Snyder and Hoffman now turned their attention to the next design called Arup S-4, which was essentially a second S-3 but with further minor modifications to the control surfaces. The aircraft first flew in 1935 and continued to fly until the outbreak of World War Two. One of the last designs Snyder produced was a low aspect ratio twin-engined monoplane, but it never progressed much further than the drawing board. At the beginning of World War Two the Arup aircraft were donated to scrap metal drives and that was the end of this story, although a scale replica of Arup S-2 was built and flown in 1985. There can be little doubt that these aircraft had a considerable influence on Charles Zimmerman who worked for NACA and was responsible for designing the better-known Chance Vought 'Flying Pancake'.

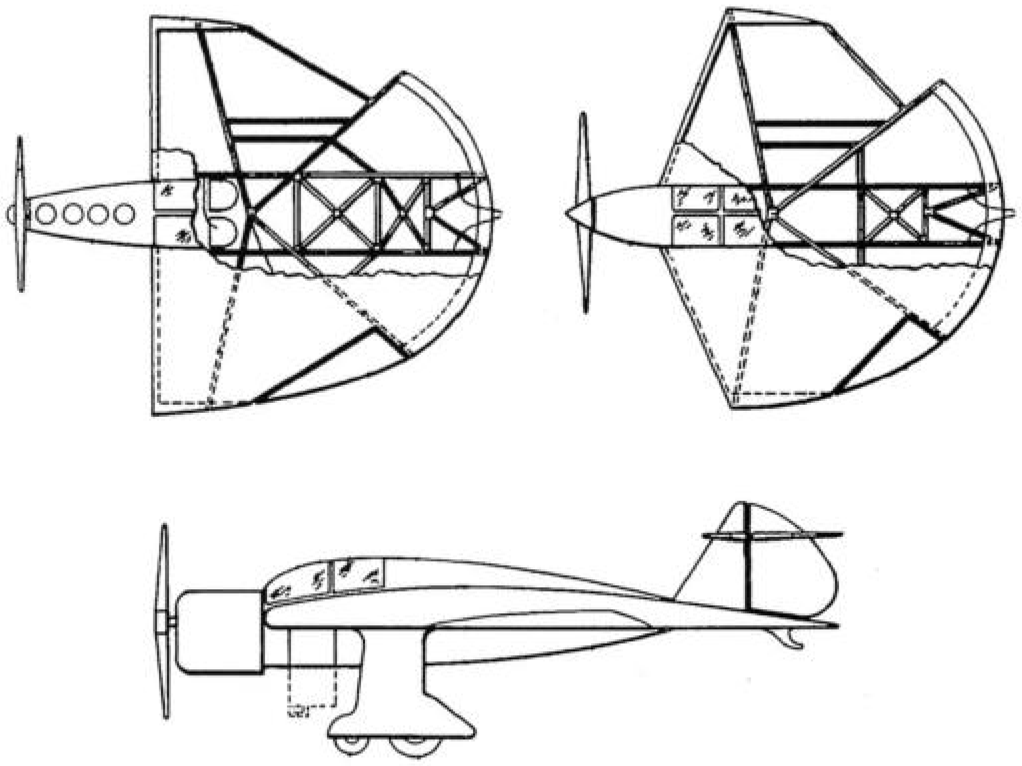
Crook's Design Studies

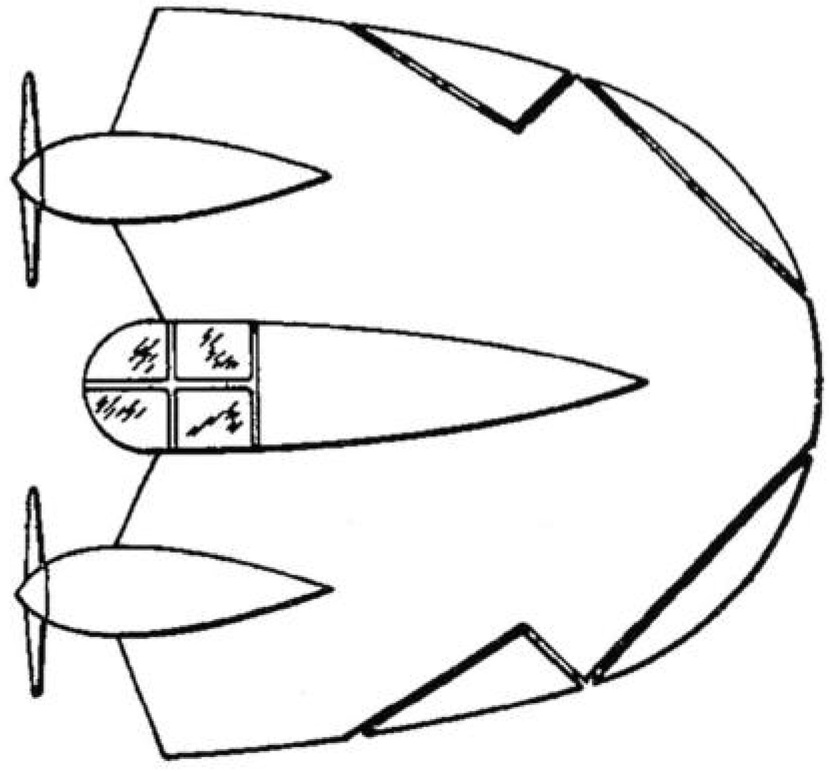
Dr Louis Henry Crook (1887-1952) was a highly respected aerodynamicist who worked for the Naval Aerodynamical Laboratory, taught theoretical and applied mechanics at the Catholic University of America, and undertook research as an aviation consultant. His area of expertise was wind tunnel testing and he wrote many papers on aviation subjects ranging from pure aerodynamics to ideas about supersonic flight and guided missiles.

During the 1930s Dr Crook became interested in Arup-type aircraft and he started to develop improvements to the basic design. Crook noted that, although the low aspect ratio configuration produced a low lift coefficient at small angles of attack, it also provided a number of interesting advantages that included increased stability. However, Crook went on to suggest that low aspect ratio airfoils were particularly suitable to what he described as thrust augmentation (which would now be called an internal ducted fan arrangement) and he went on to consider the future use of a gas turbine.



Arup S-2 and Arup S4 outside the company's hangar at South Bend in Northern Indiana. Circa 1936. via Bill Rose

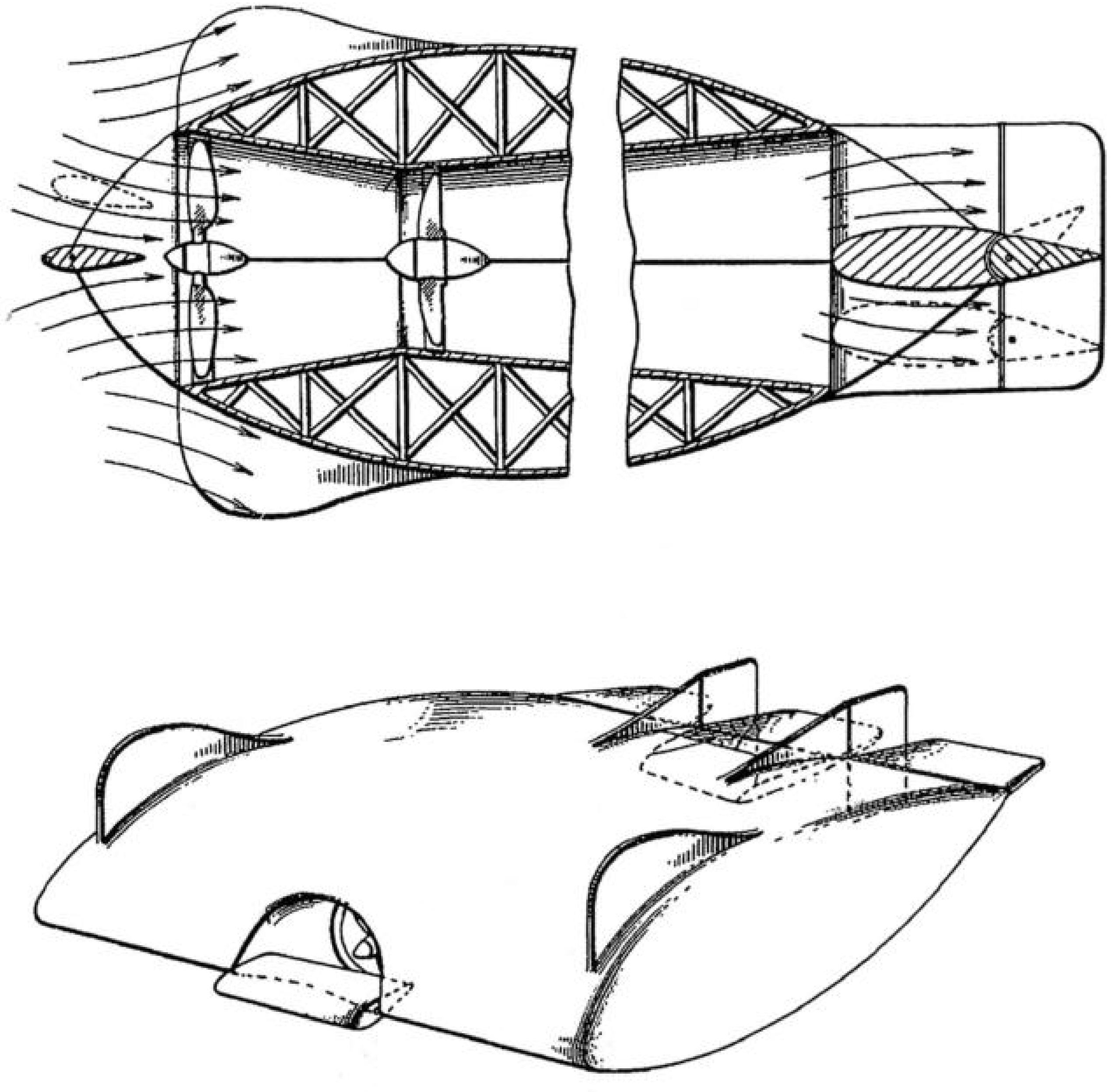




Above left: **Snyder and Hoffman produced a number of advanced designs to succeed S-4, but they were never built.** via Bill Rose

Above right: **This twin-engine design was completed by Cloyd Snyder in the late 1930s, but it was never built. Notable similarities between this concept and the later work of Charles Zimmerman are apparent.** via Bill Rose

Right: **Dr Louis Crook designed this ducted propulsion monoplane. It was completed in 1942 and kept secret until after World War Two.** US Patent Office



Filed Feb. 19, 1942

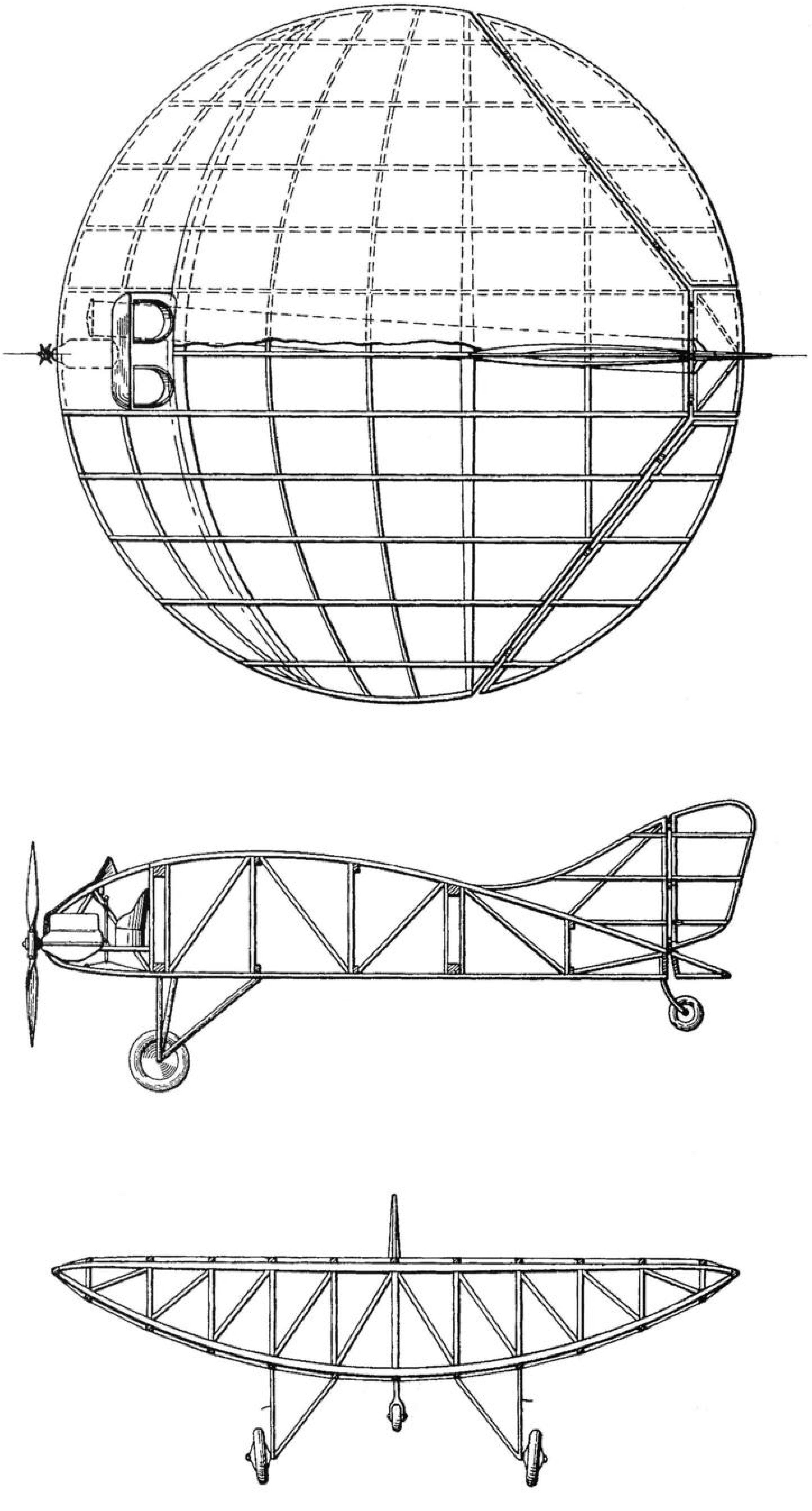
Louis H. Crook

By the late 1930s Crook had undertaken a series of largely theoretical design studies using ducted fan propulsion and he clearly appreciated the way that internal space could be fully utilised in a heel-shaped aircraft. However, these were essentially research papers and his drawings showed no provision for a cockpit, payload or undercarriage. The work was completed in 1942 and appears to have been classified as 'Secret' until the end of the war, but there can be little doubt that Crook's studies on low aspect ratio aircraft proved influential.

Johnson's Uni-Plane

Richard Burton Johnson had been interested in aviation throughout his school years and in 1931 he started attending an evening course in aerodynamics at the Chicago Aeronautical University. As part of his project Johnson was encouraged to design a small aircraft, which he called the Centricopter. He was especially interested in the idea of VTOL or STOL and conceived a circular-winged aircraft with a central rotor to generate lift.

Johnson may have built a scale model of his monoplane design, but he soon aban-



US patent for the Uni-plane filed in August 1931. Conceived by Richard Johnson, it flew on several occasions during the 1930s but the design was flawed from the outset. US Patent Office

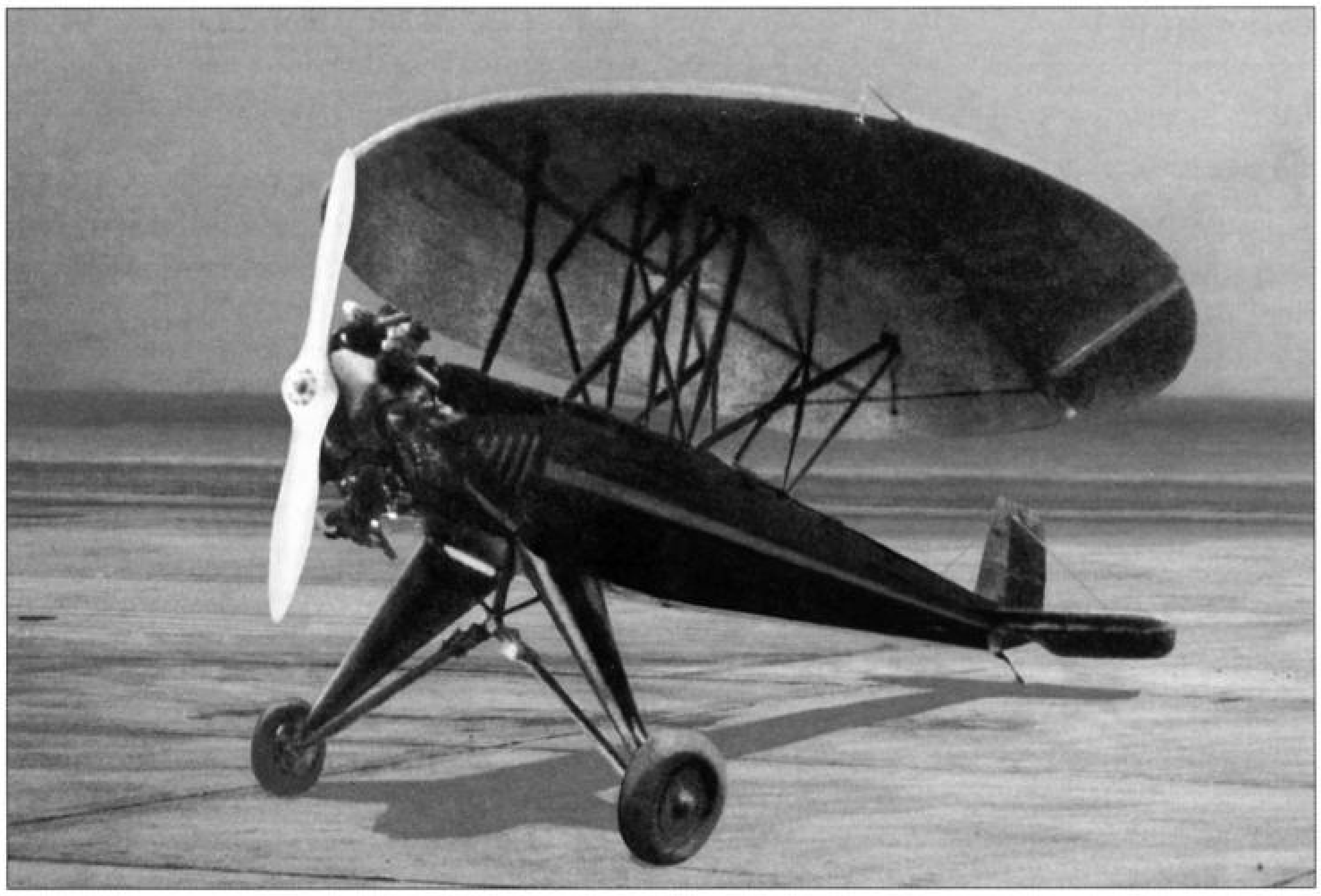
doned the idea of using a lift fan because existing engines had insufficient power to make the idea workable. Therefore he reconfigured his concept to a circular wing-shaped aircraft and in August 1931 filed a US patent (1,887411) for the design. Having called his new proposal the Uni-plane, Johnson started looking around for financial support to build it. But these were hard times in America and he was unable to find the necessary backing. After an intense effort, Johnson managed to raise about $1,000 for his venture and construction of a prototype began in the garage of his parent's home in Chicago.

The aircraft was 16ft 6in (5m) in length, with a 14ft (4.26m) span. The 3ft (914mm) thick wing was built around a Church monoplane fuselage and Johnson altered his original design to accommodate two tailfins and fitted an elevator between them. A forward-mounted compact 41hp (30.5kW) Church Marathon J-3 four-cylinder piston engine was used to drive a two-blade propeller and the aircraft's final gross weight was 650lb (295kg). Uni-plane's undercarriage was fixed, comprising two forward wheels and one smaller tailwheel, and there was enough additional room in the cockpit for one passenger. Before the aircraft flew however, Johnson rather foolishly decided to start the engine inside the garage. This was a really bad idea because the throttle jammed wide open, which made for a very dangerous situation. As the aircraft began to move it was damaged and the whole episode could have very easily ended in tragedy.

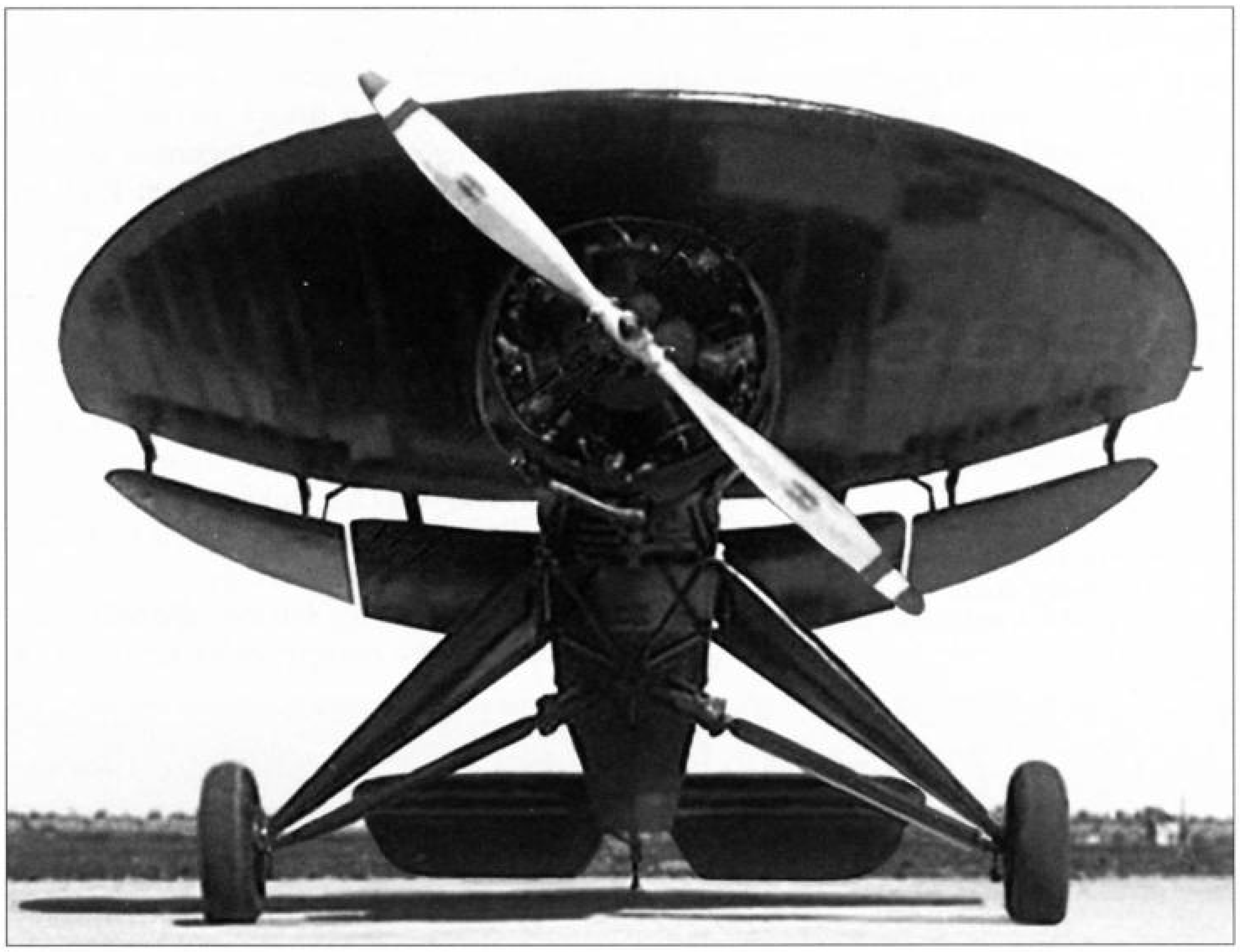
During the Autumn of 1934, Johnson moved his aircraft to Stinson Airport, where he made approximately two hundred very short 'straight line' flights, which in some cases were little more that lift-offs lasting for just a couple of seconds. He finally managed to make two circuits of the airport but both resulted in very hard landings, causing damage to the aircraft and various minor injuries to Johnson. He had been hoping to earn some money by using Uni-plane for advertising purposes, but the two accidents put a swift end to that idea.

Although Johnson made a number of alterations to the control surfaces, he finally ditched the twin tailfin arrangement, settling for a single fin, which was the way the Uni-plane had originally been designed. He then

Inventor Steven Nemeth was responsible for designing this aircraft called The Roundwing in 1934. The design was not a great success. via Bill Rose



Enjoying an excellent STOL capability, the Roundwing could take-off in 63ft (19m) and land in 25ft (7.6m), although the aircraft failed to attract commercial interest. via Bill Rose



moved to Harlem Airport and made a further one hundred short take-offs, followed by half a dozen attempts to fly a circuit of the field, which all resulted in hard landings and minor damage to the aircraft. Eventually Johnson managed two brief low-altitude flights after boosting the engine performance with higher-octane fuel. In the end however, the power-to-weight ratio was never adequate enough to make this design viable, despite the aircraft having plenty of lift. Three further accidents followed and in 1936, Johnson finally decided to call it a day, selling the aircraft to pay for his hangar facilities at the airfield. The fate of Uni-Plane is unknown, but it was probably broken up for scrap.

The Roundwing

Steven Paul Nemeth began designing circular-winged aircraft in 1926 and eventually completed a large flying model, which during 1929 was wind tunnel tested at the University of Michigan. The results were good enough to encourage him to design a full-sized aircraft, which was built as an experiment by students at Miami University (Ohio) and completed in 1934. The aircraft was called the Roundwing although, rather confusingly, it was also sometimes known as the Umbrellaplane.

The Roundwing used a stretched Alliance Argo fuselage with a conventional tail and was powered by a forward-mounted 90hp (67kW) Lambert piston engine, which drove a two-bladed propeller. Overall length of the Roundwing was 20ft (6m) and the span of the circular wing was 16ft (4.8m). The aircraft was successfully flown at Curtiss Airport and progressively rebuilt over the next two years. In 1936 it was fitted with a more powerful 120hp (89.5kW) Warner Scarab engine and considerable work was carried out on the wing. It was said that the Roundwing could take off in 63ft (19m) and land in 25ft (7.6m) at only 30mph (48km/h), which remains very impressive. Maximum speed was 140mph (225km/h) and it was also very stable and apparently incapable of stalling. Nemeth hoped to manufacture the Roundwing for $1,400 per copy, but there were no takers and the plan was finally abandoned.

Henri Coanda

Henri Marie Coanda (1886-1973) was one of the greatest aerodynamicists and inventors of the 20th century. He pioneered a form of jet engine long before the arrival of the gas turbine and discovered a very significant airflow phenomenon that became known as The Coanda Effect.

Born to an academic Romanian middle-class family, Coanda grew up in Bucharest and eventually joined the School of Military Artillery. After graduating as an artillery officer, he developed an interest in aviation and continued his studies at the Montefiore Institute in Liege, Belgium. On his return to Romania, Coanda undertook a short term of service with the military and then enrolled at the Superior Aeronautical School in Paris, graduating in 1909.

In 1910, he built what is now regarded as the world's first jet aircraft, in Joachim Caproni's workshop, and gave it the rather uninspiring name Coanda-1910. This aircraft was not equipped with the instantly recognisable type of gas turbine we associate with Frank Whittle and Hans von Ohain. The sys-

Coanda-1910

Type	Research biplane
Accommodation	One
Engine	Integral 'Thermojet' reaction engine system driven by a 50hp (37kW) internal combustion engine. Thermojet rated at 485 lb (2.15kN) thrust.
Length	41ft (12.5m)
Wingspan	33ft 9½in (10.3m)
Weight	925 lb (420kg)
Only Reported Test Flight	October 1910
Fate	Aircraft destroyed at Issy-les-Moulineaux Airfield, France, during demonstration on 16th December 1910.

tem used in Coanda-1910 took the form of a steel-panelled duct enclosing a water-cooled 50hp (37kW) four-cylinder piston engine turning a compressor fan at 4,000rpm – Coanda called this system a thermojet. A large adjustable iris (called an orburator), which was controlled by the pilot, regulated the airflow. The engine exhaust and additional fuel were fed into two ring-shaped combustion chambers that generated thrust. The exhaust gases exited at the rear end of the duct.

The aircraft was displayed in October 1910 at the Grand Palais on Champs-Elysées in Paris, where the Second International Aeronautical Exhibition was held. Many visitors were attracted to the strange-looking single-seat red biplane that had no propeller. This generated considerable public debate about whether Coanda's machine was actually capable of flight. When the exhibition closed on 16th December 1910, Henri Coanda had his aircraft transported to the Issy-les-Moulineaux airfield in readiness for a public demonstration.

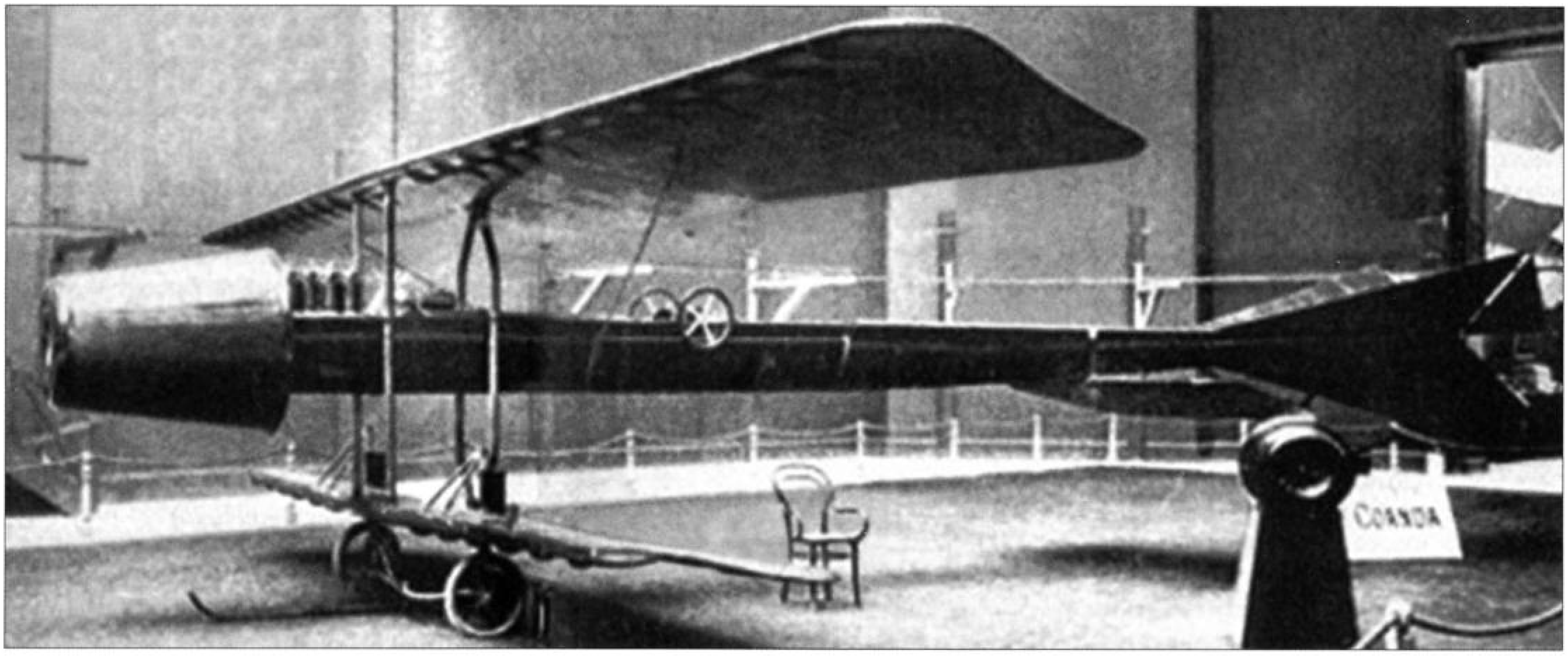
Henri Marie Coanda, one of the greatest aerodynamicists and inventors of the 20th century.
via Bill Rose

After a spectacular fiery start, the aircraft moved off in a cloud of smoke. It was piloted by Coanda, who briefly left the ground but then lost control of the aircraft. Coanda-1910 hit the ground, tipped over, caught fire and was destroyed. Coanda was lucky enough to escape with minor injuries, but the lack of interest shown by the aviation community led him to abandon any further experiments with this new type of propulsion.

Several decades later, a fresh attempt to use the thermojet would result in two prototype Campini-Caproni CC-2 aircraft being built and flown, but the project was soon buried by the gas turbine's arrival. In 1911, Coanda joined the Bristol Aeroplane Company in England as their technical director and remained with the firm until 1914. He then went to work for the French company Dalauney-Belleville Airplanes at Saint Denis, where he designed three different aircraft.

During the crash of the Coanda-1910 aircraft, Coanda had subconsciously noticed the way that flames and incandescent gas tended to flow along the fuselage. Some time later, after World War One, this casual observation turned into a more serious quest for knowledge and Coanda started experimenting with jets of steam, aware that they tended to flow around nearby curved surfaces. When he finally published his findings, this brilliant discovery earned him universal recognition and become known as The Coanda Effect. In 1935, Coanda used this aerodynamic phenomenon for the basis of an entirely new type of aircraft, which he called Aerodina Lenticulara. In almost every respect it was a classic flying saucer design, which established many of the ground rules followed later by aircraft designers such as Loedding, Frost and Price.

In the immediate post-war years, Henri Coanda was invited by the USAF to present a lecture on his flying saucer concept at Wright-Patterson AFB. In 1969 he returned to Roma-

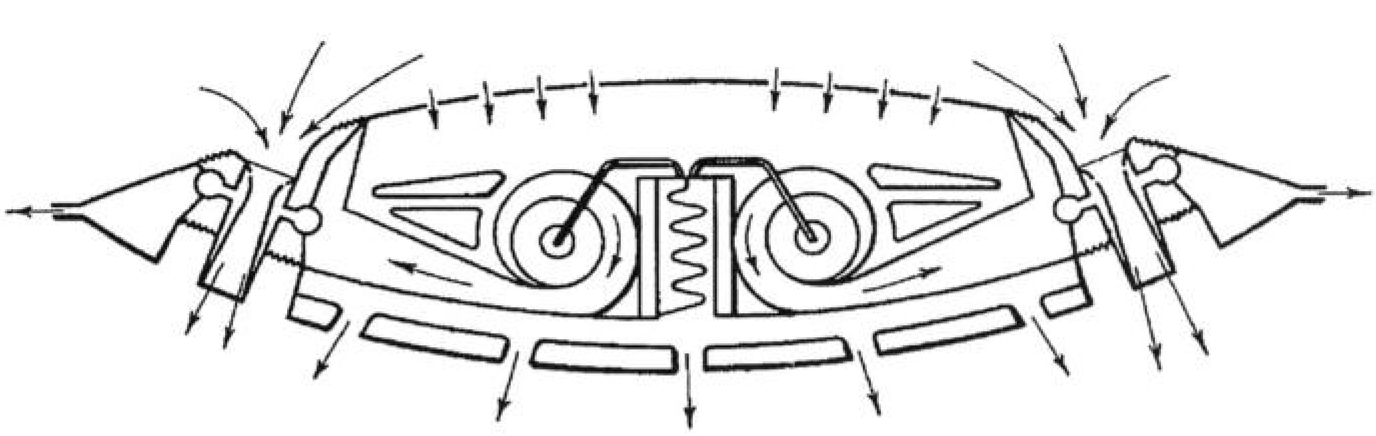


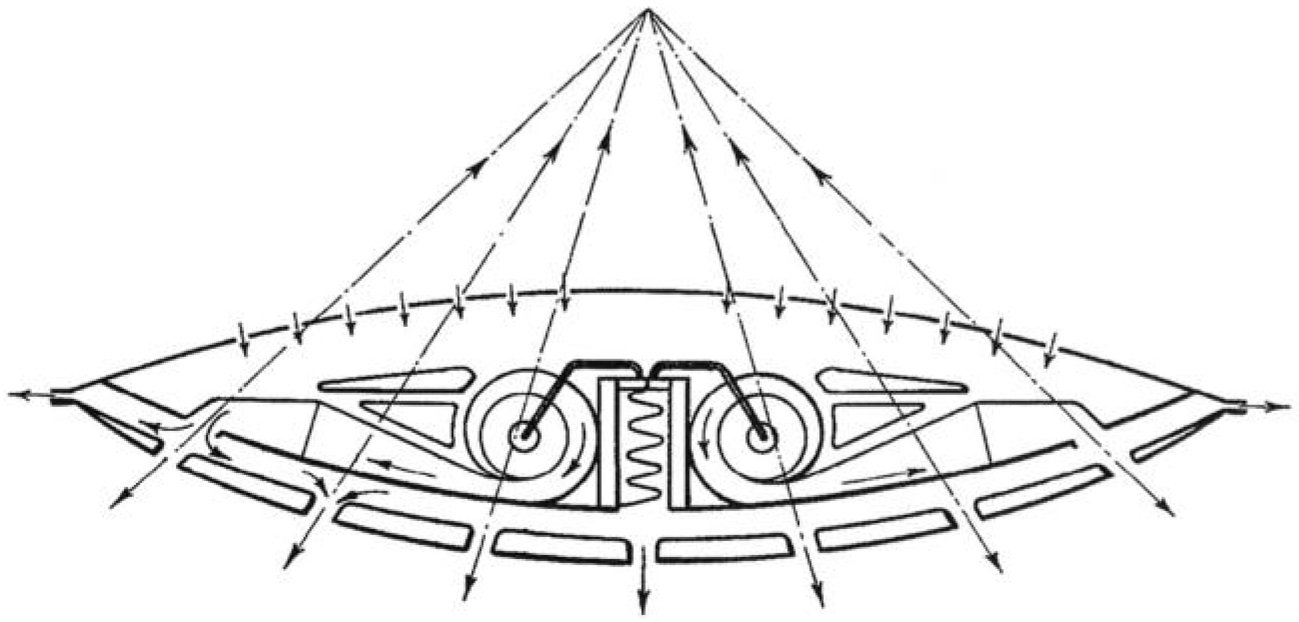
Coanda-1910. The world's first jet aircraft, built in 1910 at Joachim Caproni's workshop. It used a form of propulsion called the *Thermojet*.
via Bill Rose

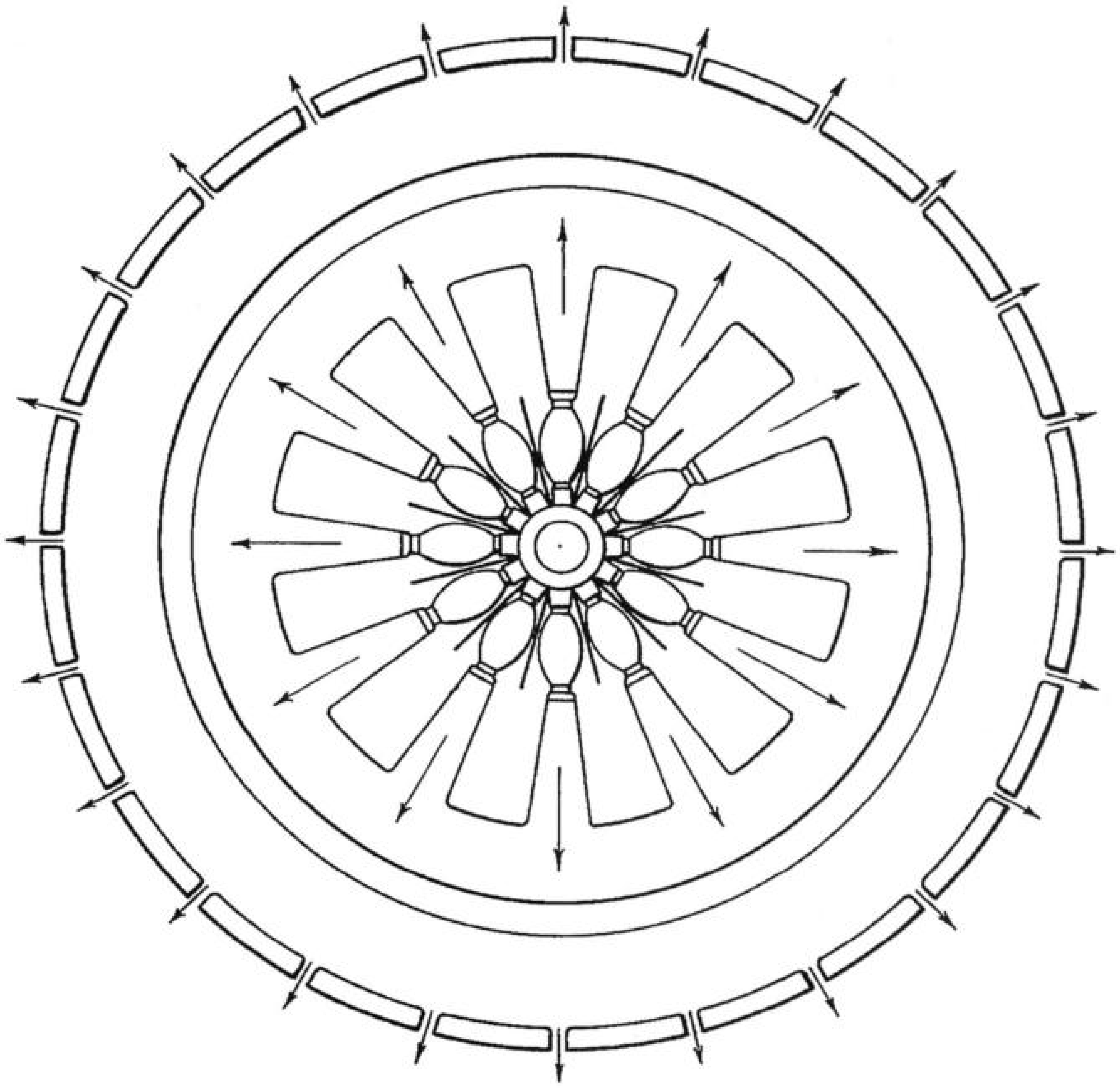
Right: **Schematic showing the principal design features of the later Coanda lenticular vehicle.** US Patent Office

Below right: **Operating features of Coanda's revised design for the lenticular vehicle.** US Patent Office

Bottom right: **Planform drawing of the later Coanda lenticular vehicle.** US Patent Office







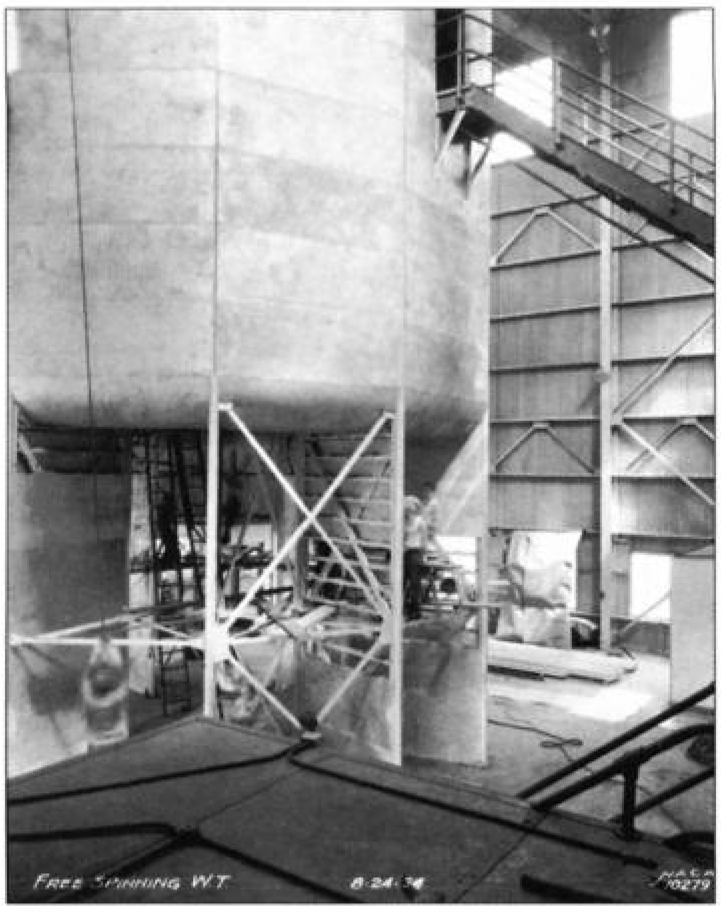
nia, becoming Director of the Institute for Scientific and Technical Creation, and he died in Bucharest on 25th November 1972. During his lifetime Coanda was responsible for many significant advances in aeronautics, which would place him amongst the pioneers of aviation. As a sign of respect in Romania, Bucharest's International Airport has been named after him.

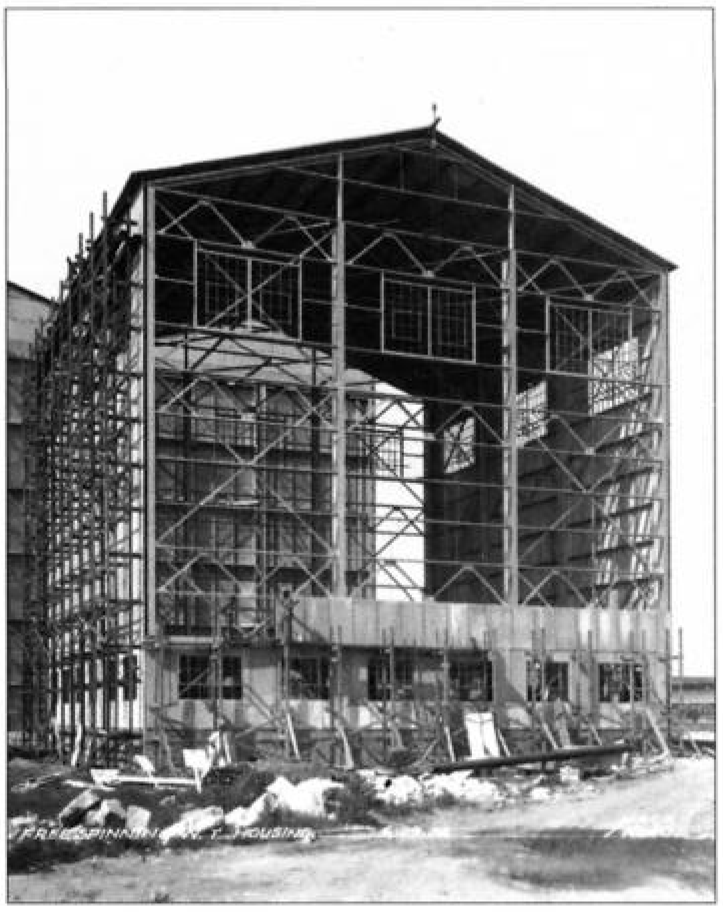
Zimmerman's Flying Pancake

While studying electrical engineering and basic aeronautics at the University of Kansas during the late 1920s, Charles Horton Zimmerman (1907-1996) became involved with wind tunnel development for NACA. Working on a new open-throat wind tunnel for the Langley Memorial Aeronautical Laboratory, Zimmerman's proposals finally earned him a full-time job with the Agency in 1929. Once this new state-of-the-art Vertical Wind Tunnel was in operation, Zimmerman was assigned to the development of two much larger wind tunnels, which were funded during 1933 and completed in early 1935.

Zimmerman also found enough spare time to design an advanced aircraft during this period. He was undoubtedly encouraged by the work undertaken by Cloyd Snyder and two lesser-known Chicago-based inventors, Steven Nemeth and Richard Johnson, who designed, built and flew small circular-winged aircraft during the early 1930s. Zimmerman wanted to take their ideas a stage further and he envisaged a near-circular low aspect ratio shape that would fly faster and higher than any other aircraft, while retaining the ability to hover like a helicopter. Although the limitations of internal combustion engines made this idea virtually impossible, Zimmerman still received a prestigious NACA award for his creative concept.

With the assistance of Richard Noyes and John McKeller, Zimmerman continued to refine his unusual semi-circular winged ideas and completed a small aircraft, although it never flew because of engine problems. Perhaps this was for the best because many considered his contraption rather dangerous. Nevertheless, in 1936 he was able to prove that the concept worked, using nothing more





HIGH SPEED WIND TUNNEL
4-6-34
NACA 9647

NACA wind tunnels:

Above, left to right: **15ft Spin Tunnel at NACA Langley 1934; 15ft Spin Tunnel at NACA Langley 1935; This photograph shows NACA Langley's 15ft Spin Tunnel building during the construction phase in 1934.** All pictures NASA

Left: **24-inch High-Speed Tunnel, 1934.** NASA

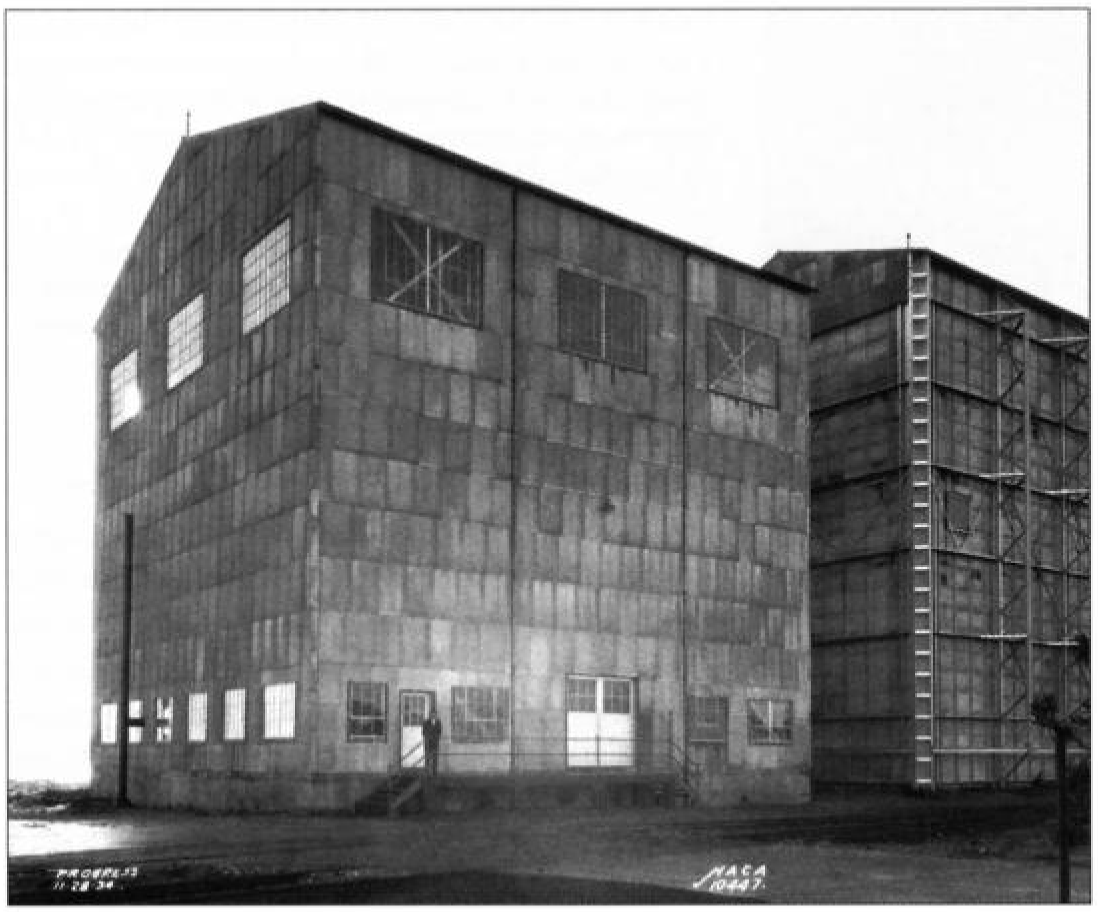
than a remarkably simple 20in (508mm) rubber band-powered model.

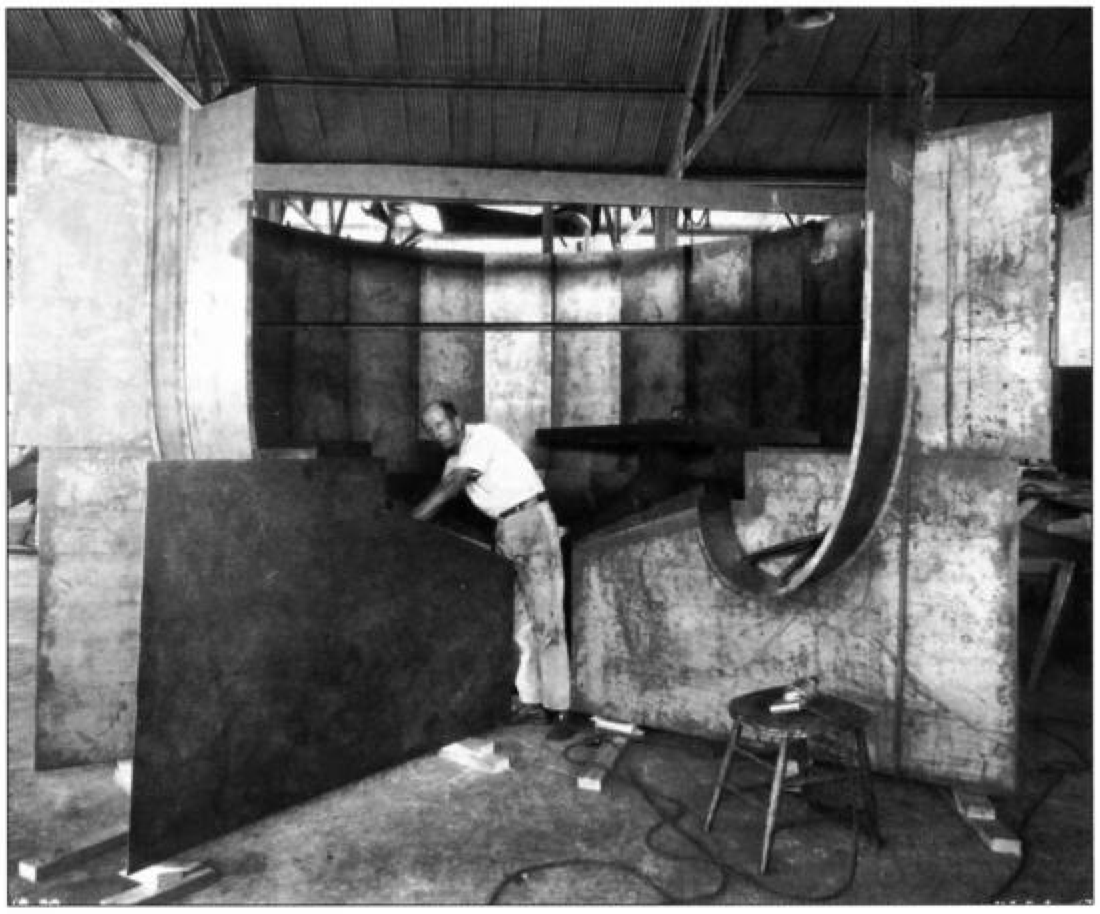
In 1937 these projects caught the attention of United Aircraft Corporation's President Eugene Wilson and, although Zimmerman was now the head of NACA's Stability and Control Section, he accepted a designer's job at the company's Chance Vought Aircraft Division, situated at Stratford, Connecticut. This gave Zimmerman the opportunity to construct an advanced model-sized circular-winged demonstrator called V-162. Company records indicate that this electrically-powered tethered model flew extraordinarily well inside a hangar and showed remarkable STOL potential.

In February 1938 Zimmerman filed a US patent (2,108093) for a semi-circular low aspect ratio aircraft, which he called the Aeromobile. The design was driven by twin propellers, which provided an estimated performance range of 0-200mph (0-322km/h) and carried a pilot and two passengers in prone positions. By the time his Aeromobile design had been finalised, Zimmerman had progressed to a military utility version, called the V-170, which Vought offered to the US Army in late 1938.

The Army were impressed with his concept, but finally turned down a development proposal, probably because Chance Vought was primarily a US Navy contractor and inter-service attitudes made them reluctant to proceed in this direction. But the following year, after a merger with Sikorsky, senior officials at Vought managed to attract Navy interest in Zimmerman's work. This led to a series of wind tunnel tests at Langley Field using scale models and a US Navy contract to build a single 'proof of concept' prototype known as the V-173. This was essentially a scaled-up, man-carrying V-162, powered by two modest piston engines.

The first proposal for the V-173 featured a prone position for the pilot to improve streamlining and before long a wooden mock-up of the cockpit had been built. By the time assembly of V-173 began, horizontal stabilisers had been attached to the tail of the aircraft and the cockpit was fully redesigned so the pilot could sit in a more conventional upright position. In late 1941, the V-173 prototype was shipped to Langley and tests began in the Full Scale Wind Tunnel, with two-bladed propellers fitted. As a consequence of this lengthy series of trials, various modifications were made to the aircraft and the two-blade propellers were replaced with a three-blade type.





Above: **Exterior of the completed 15ft Spin Tunnel Building at NACA Langley 1935.** NASA

Above right: **NACA Langley's 5ft High-Speed Wind Tunnel under construction.** NASA

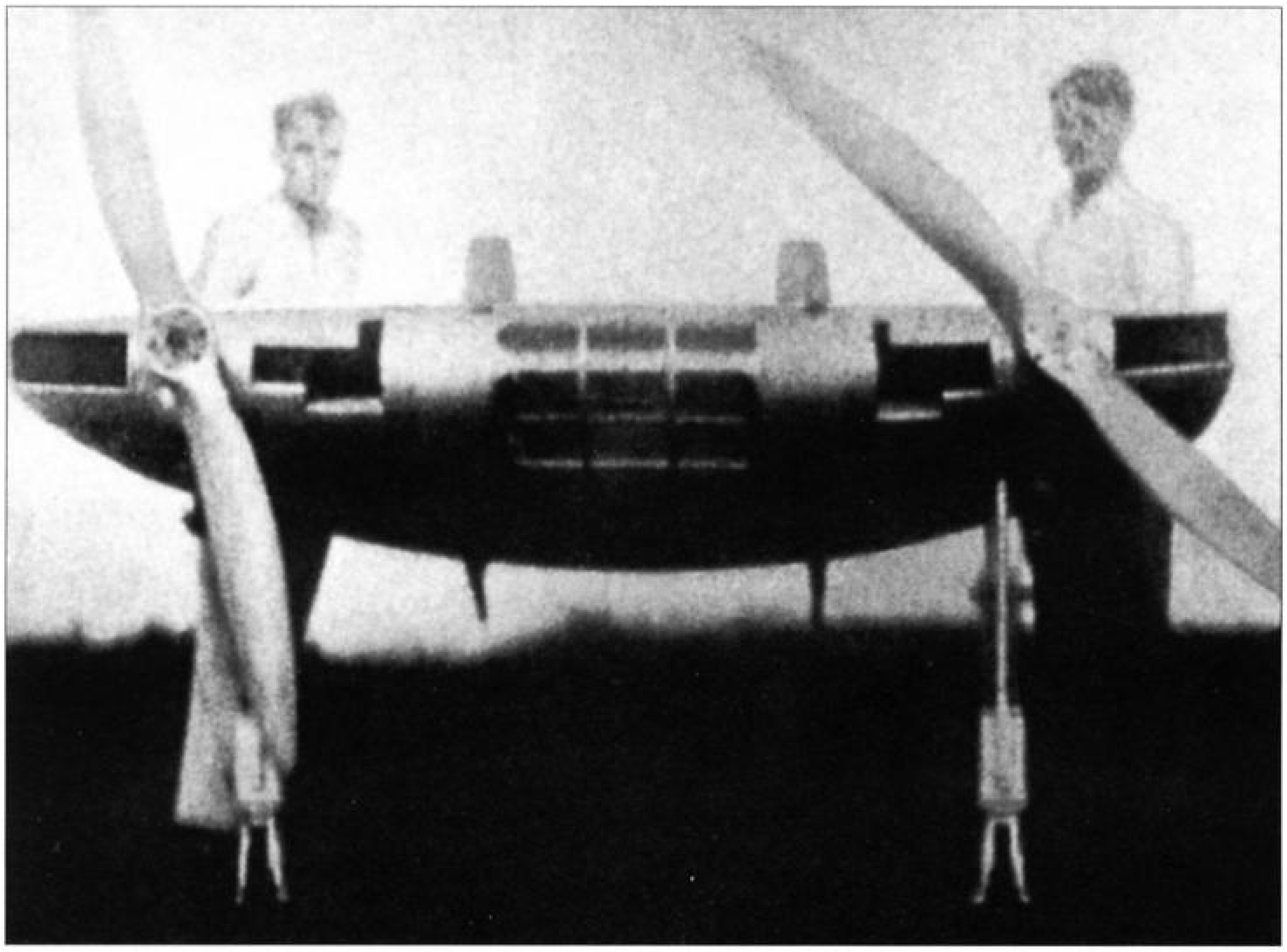
Right: **5ft Vertical Spin Tunnel at NACA Langley in 1932.** NASA

While trials of the V-173 continued at Langley, it was becoming clear to the Navy that aircraft carriers had become the most important type of warship in any major battle group. Mobile floating airfields offered a new level of power projection and the Japanese Navy had demonstrated their effectiveness on 7th December 1941, when a devastating surprise attack was launched against US warships belonging to the US Pacific Fleet that were anchored in Pearl Harbor. If STOL or, ideally, VTOL fighters based on V-173 proved viable, this might allow the use of much smaller aircraft carriers, converted merchant ships or simply the carriage of more warplanes by bigger vessels.

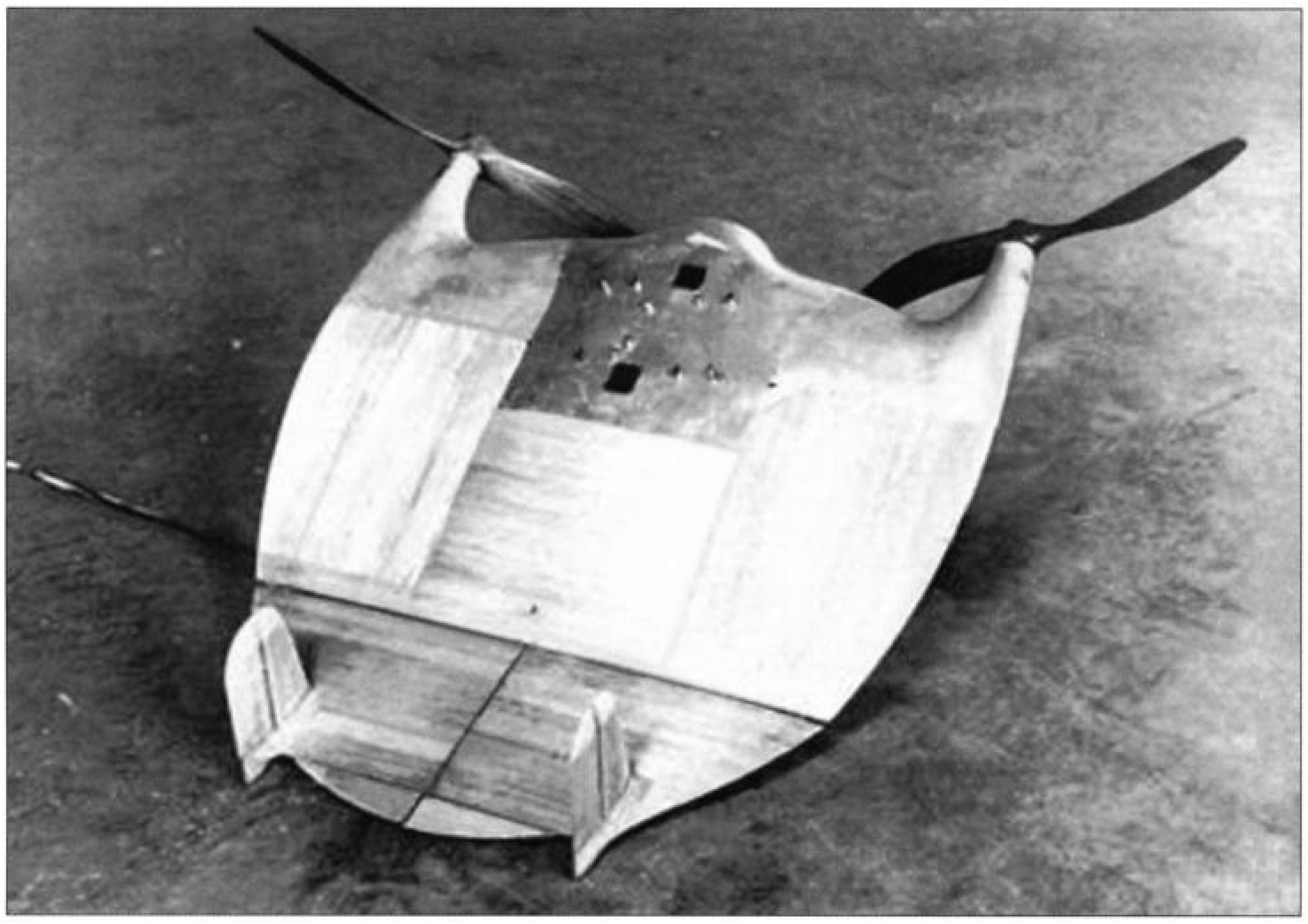
At the start of November 1942, V-173 was ready for its first test flight at Stratford and on 23rd November the company's senior test pilot, Boone Guyton, took the V-173 on a brief trip around the perimeter of the company's airfield. By now, the aircraft was being referred to as the 'Flying Pancake'. Although the flight was relatively uneventful, Guyton found that the controls were very sluggish and this was later traced to improperly balanced control surfaces.

That aside, the V-173 completed its first test circuit, which lasted for 13 minutes and the aircraft touched down safely on the runway in an astonishingly short distance, said to have been less than 50ft (15m). The V-173 was 26ft 8⅜in (8.13m) in length, it had a 23ft 3⅝in (7.16m) wingspan and a wing area of 427ft^2 (39.66m^2). Largely constructed from wood and aluminium with a fabric covering, it weighed a mere 2,258 lb (1,024kg) and propulsion was provided by two 80hp (59.6kW) Continental A-80 piston engines. Just 16.5 gallons (75 litres) of fuel were carried, but that was more than adequate for this lightweight prototype. Although grossly underpowered, the low weight and high lift, assisted by the steeply raised undercarriage angle of 22°, would allow take-offs in less than 200ft (60m), depending on wind conditions. Maximum speed was a pedestrian 138mph (222km/h), but the V-173 was never intended to be a high-performance aircraft. It could cruise at 75mph (120km/h) with no difficulty and never stalled or showed any tendency to spin.

Piloting the V-173 was unlike any other aircraft. With both engines running at full power and the stick pulled right back, it was possible to fly with a nose-up attitude of 45°, while maintaining complete lateral and longitudinal control. In fact, because of inadequate engine power, the V-173 always tended to fly



Small piloted aircraft completed in the 1935 by Charles Zimmerman. It never flew due to engine balancing problems, which was probably for the best as the aircraft was considered rather dangerous. via Bill Rose



Vought V-162, a small proof-of-concept demonstrator model designed and built by Charles Zimmerman, who flew it at Vought's factory during 1937. Vought Heritage

nose-up although the situation was reversed during landing and all pilots agreed that controlling the aircraft could be difficult. The V-173 also suffered from significant engine noise in the cockpit, accompanied by an unpleasant resonant frequency that was generated by the propellers. Zimmerman managed to reduce this second problem with vibration dampers, but the V-173 remained a noisy aircraft throughout its life.

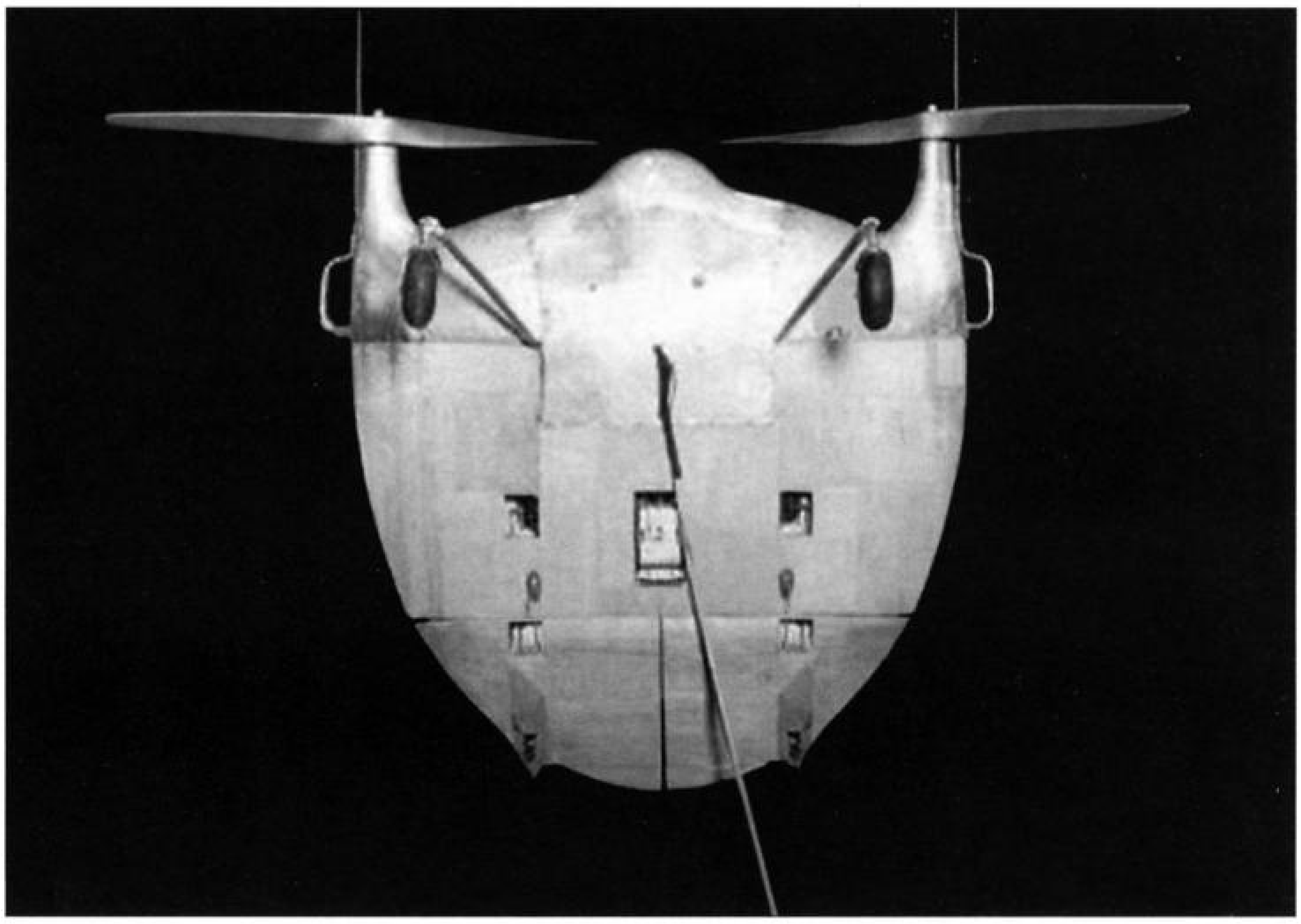
During its flight history, there were two crash landings, although damage was relatively minor in each instance. The first accident took place on 3rd June 1943, when a fuel supply problem forced Vought's test pilot Richard Burroughs to put down on Lordship Beach, just below Bridgeport on Long Island Sound. As he touched down, Burroughs narrowly avoided a sunbather and then the aircraft flipped over as its wheels sank into soft sand.

Almost two years later, Burroughs made a second crash landing on the Mill River Golf Course near Stratford after suffering engine trouble. One final near-catastrophe was narrowly avoided in 1947 at Chance Vought's 13th Anniversary Air Show, when Guyton experienced lift problems and just managed to clear some high-tension cables and a rock face near the end of the runway. After its 171st flight during the same year, trials of the V-173 were concluded and the aircraft was passed to the Smithsonian National Air and Space Museum, who placed it in storage at their facility in Suitland, Maryland, where it remained until the end of the century.

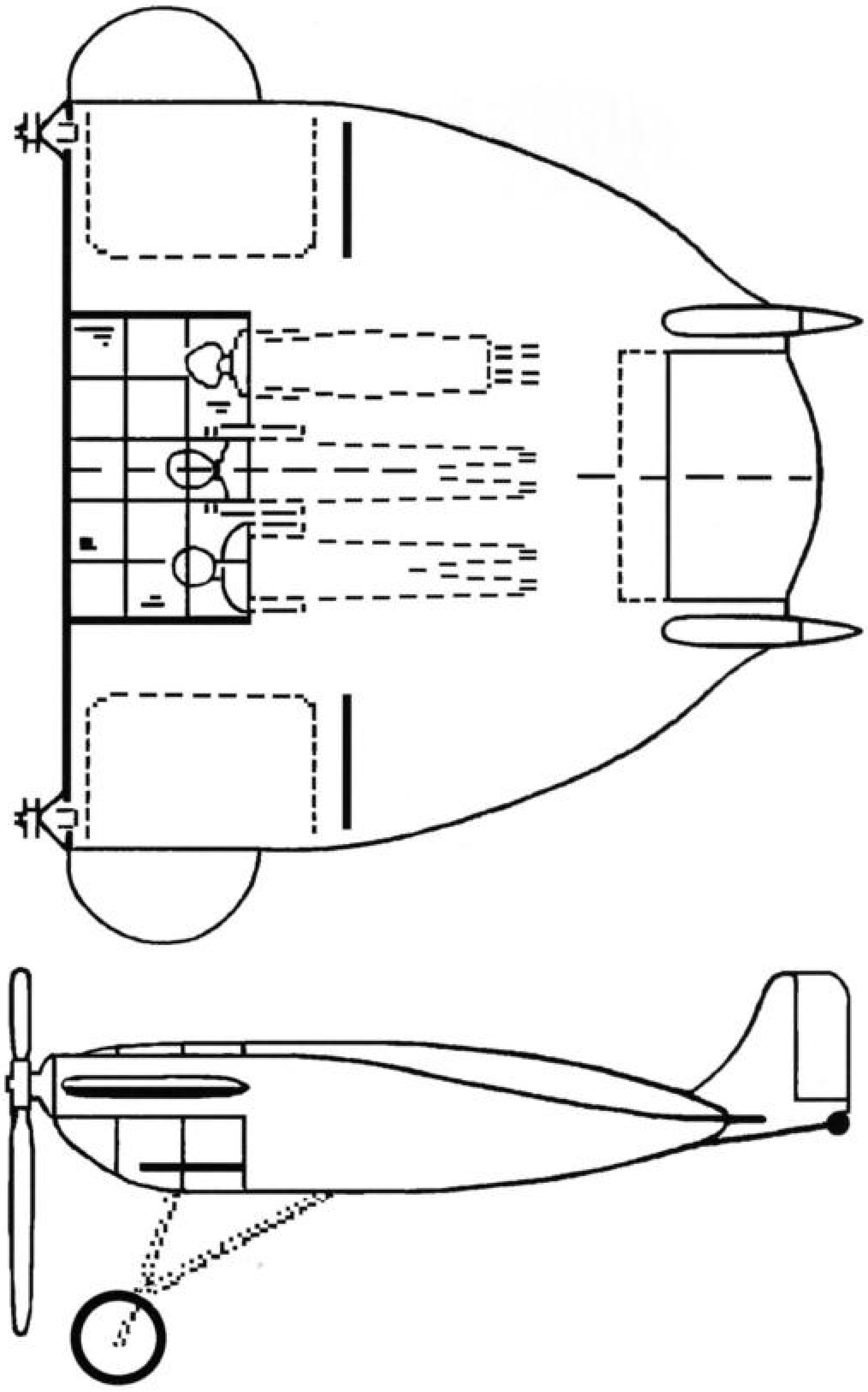
In 2000, a group of Vought retiree members of the company's Heritage Foundation talked senior museum staff into allowing them to take the aircraft away and restore it to original condition. As a result of these negotiations, V-173 was partly dismantled, crated (at a 32°-angled position) inside a large custom-built metal and plywood container and moved by flatbed truck across six states to Vought's facility in Dallas, Texas, arriving in late 2003.

Restoration work was soon under way, with a team of 22 former Vought engineers (now in their eighties) working on the historic aircraft. Amongst the tasks undertaken was a complete overhaul of both engines, replacement of the aircraft's cotton fabric skin, some cockpit Plexiglas and a number of internal

Charles Zimmerman. US Navy



Underside of Zimmerman's V-162 model demonstrator, which was flown within a Vought company hangar. The similarity between this design and the larger manned V-173 is very apparent in this photograph. Vought Heritage



Designed in 1938, this Zimmerman semi-circular low aspect ratio concept was called the *Aeromobile* and many of the design features found their way into the later V-173. US Patent Office

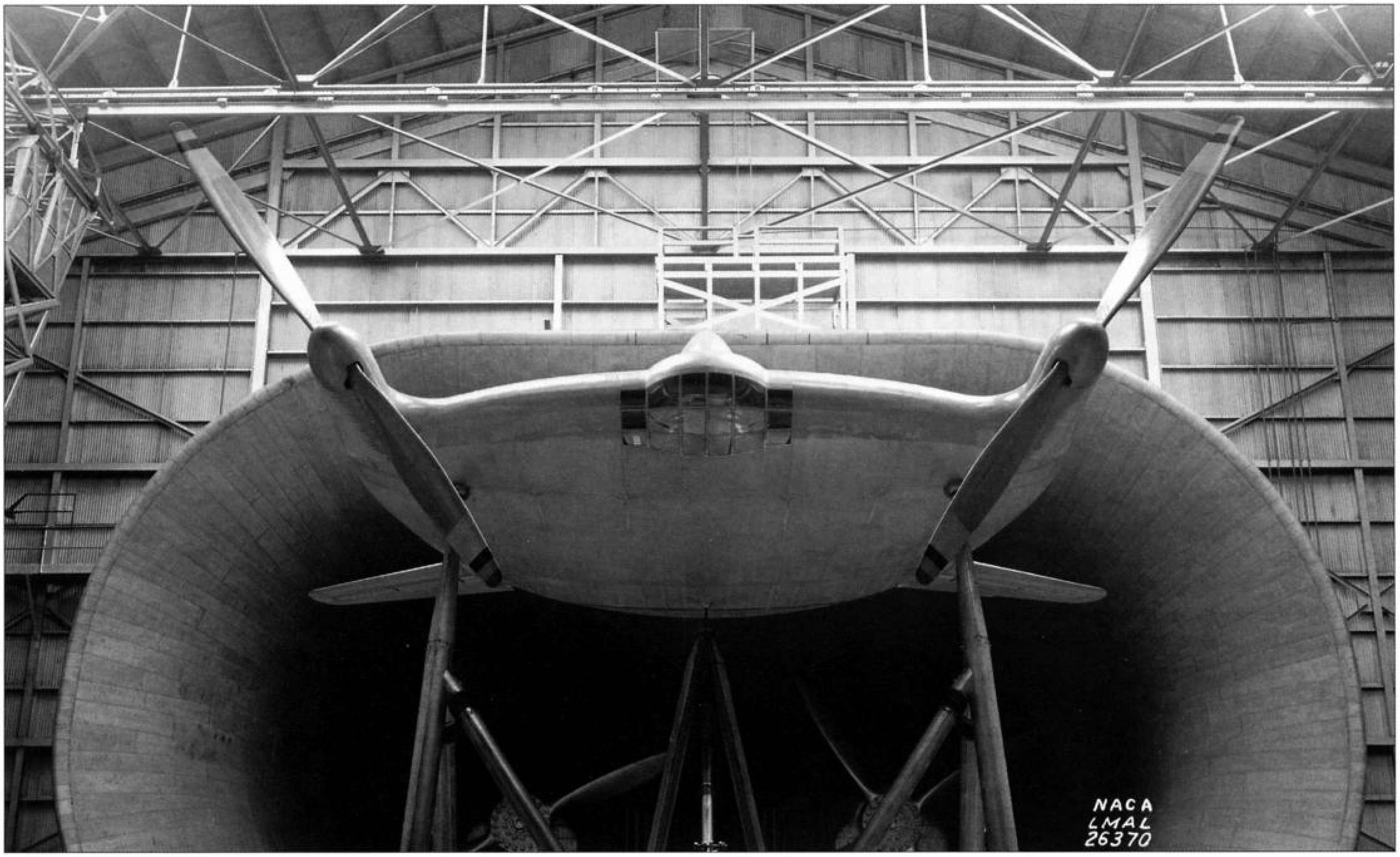
components. To make the project easier, a rotating steel framework was built which allowed the aircraft to be turned to different positions while it was being worked on. Finally, V-173 was re-painted in the original yellow and silver scheme. After exhibition at the Dallas Frontiers of Flight Museum, V-173 will be returned to the Smithsonian.

The XF5U-1

Even before the V-173 had completed its first test flight, Zimmerman was busily working on a high-performance weaponised successor called the (Vought-Sikorsky) VS-315, which would later become the Vought XF5U-1. Described in some UFO literature as a 'still secret 100ft (30.4m) wide flying saucer with rocket propulsion', the XF5U-1 was simply a second-generation V-173. Again, Zimmerman planned to use a prone pilot position, but the US Navy rejected this in favour of a modern fighter cockpit layout, with the pilot sitting upright inside a blister canopy.

While Zimmerman continued to refine his design, the Navy issued a Letter of Intent to Vought on 10th September 1942 and work finally commenced on the construction of a mock-up and two XF5U-1 prototypes, one of which was destined for destructive static testing. Known as the Skimmer or Zimmer Skimmer, but more formally referred to as the second Flying Pancake or Flying Flapjack, the XF5U-1 was conceived as a prototype long-range carrier-based fighter-bomber with exceptional STOL performance and the potential to hover at a very high inclination.

The Vought XF5U-1 was fitted with two Pratt & Whitney R2000-7 radial air-cooled engines, rated at 1,350hp (1,006kW), driving propellers through complex gearbox arrangements. This was expected to provide a performance range extending from about 50mph to 425mph (80-683km/h). Once initial trials had been completed, there were plans to install slightly more powerful Pratt & Whitney R-2000-2 (D) Wasp turbo-supercharged 14-cylinder engines rated at 1,600hp (1,193kW). Using these engines, it was predicted that the aircraft would be able to land at 40mph (64km/h) and almost reach 500mph at an altitude of 30,000ft (9,144m),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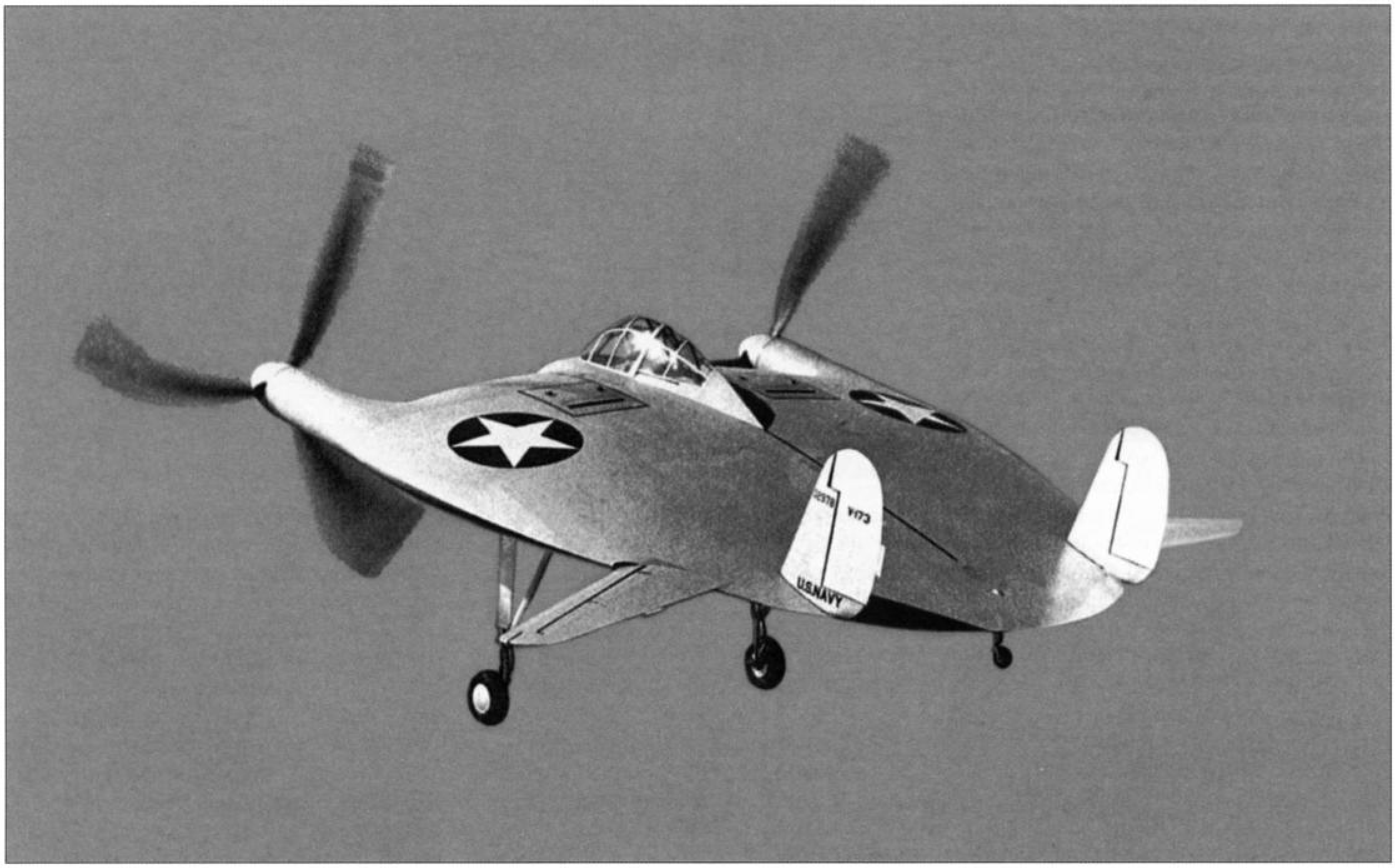

U.S. NAVY
V173

Opposite page:

Vought V-173 undergoing wind tunnel testing at NACA Langley in 1941. NASA

Vought V-173 during a test flight. US Navy

This page, top to bottom:
V-173, parked at the company airfield. US Navy

V-173 being prepared for flight. US Navy

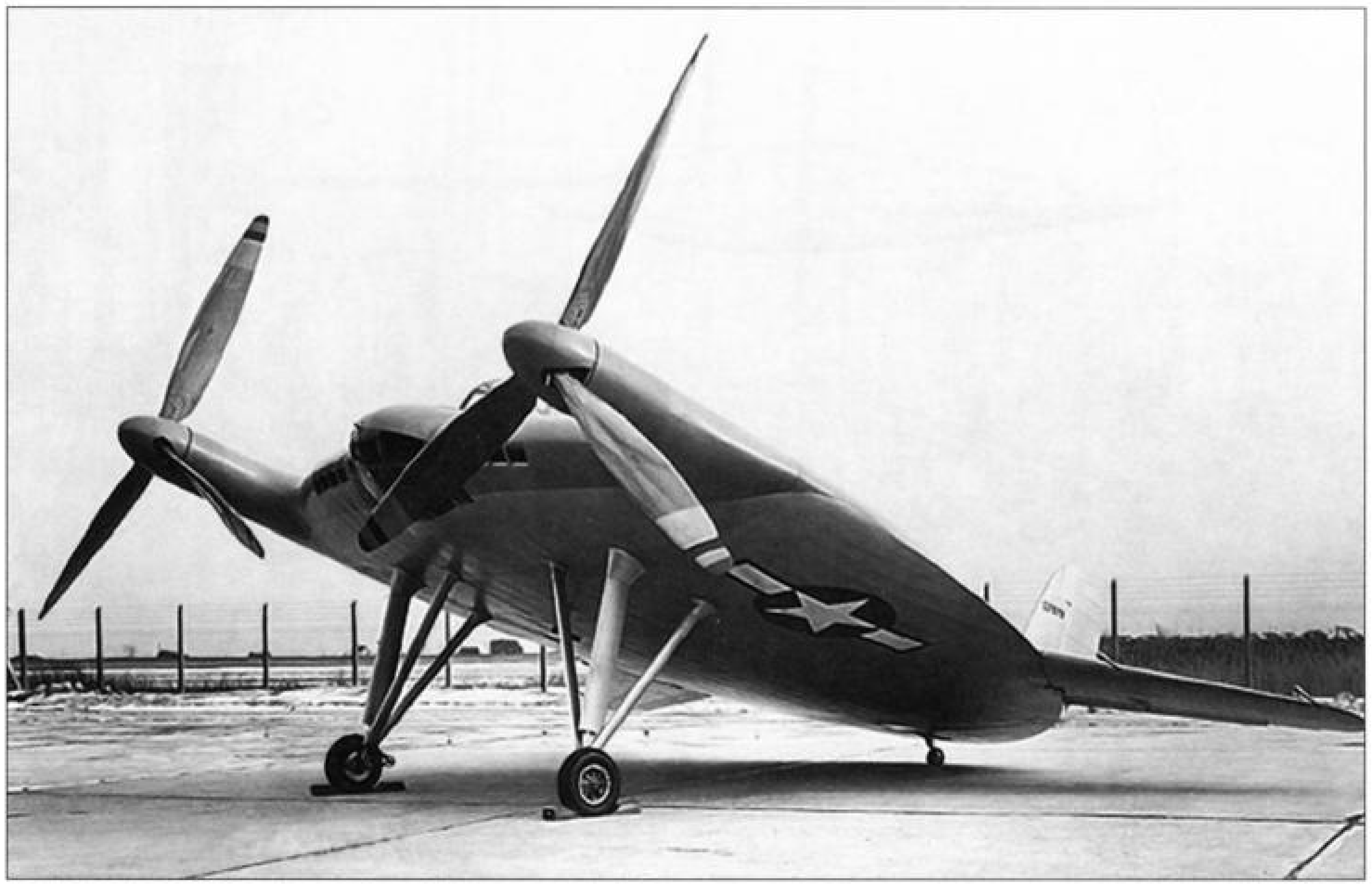
V-173 makes an emergency landing at Lordship Beach, Connecticut following a fuel supply problem on 3rd June 1943. The pilot, Richard Burrows, escaped without injury and, despite flipping over in the soft sand, the aircraft was relatively undamaged. via Bill Rose

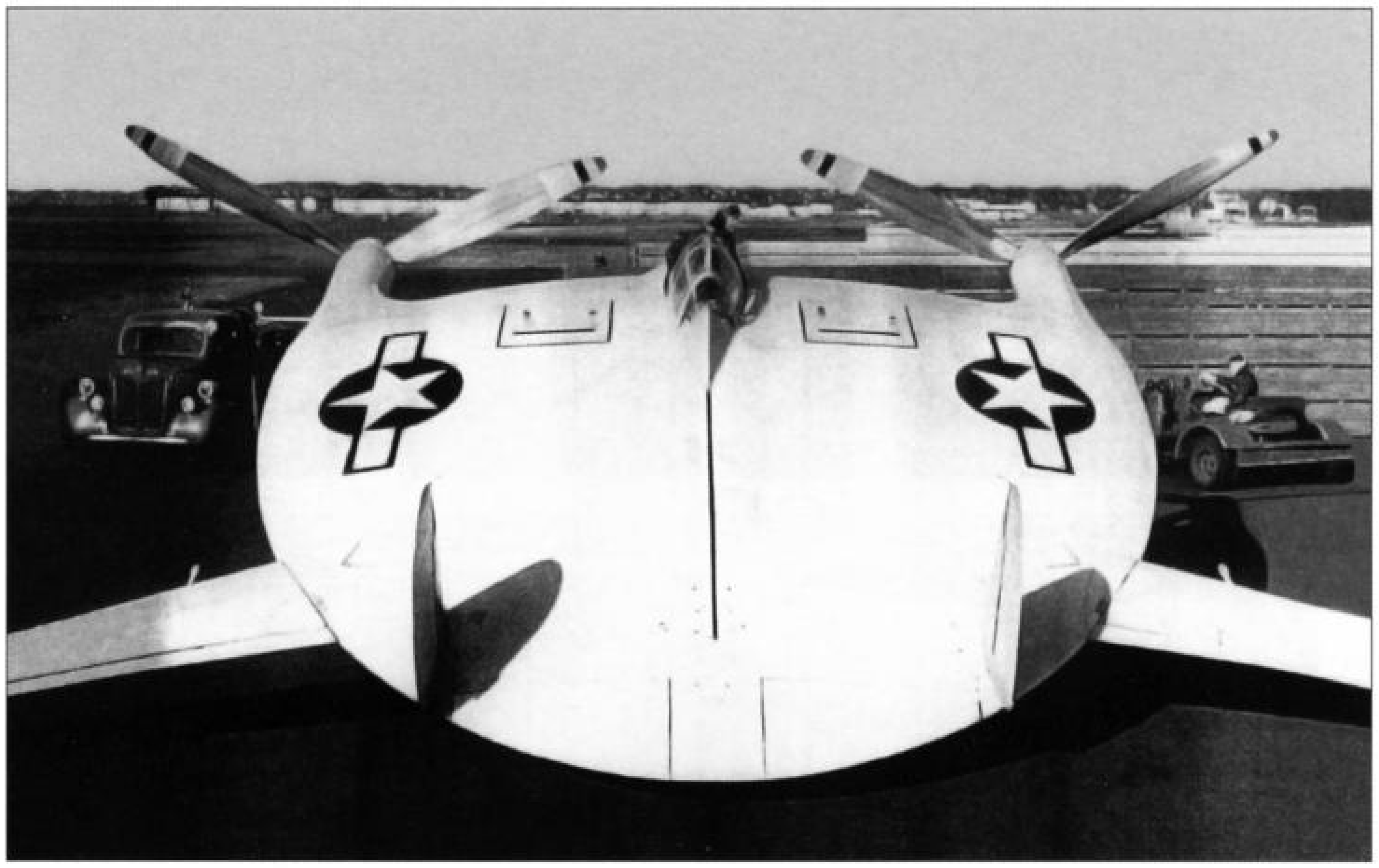
taking it towards the theoretical limits of propeller-driven performance.

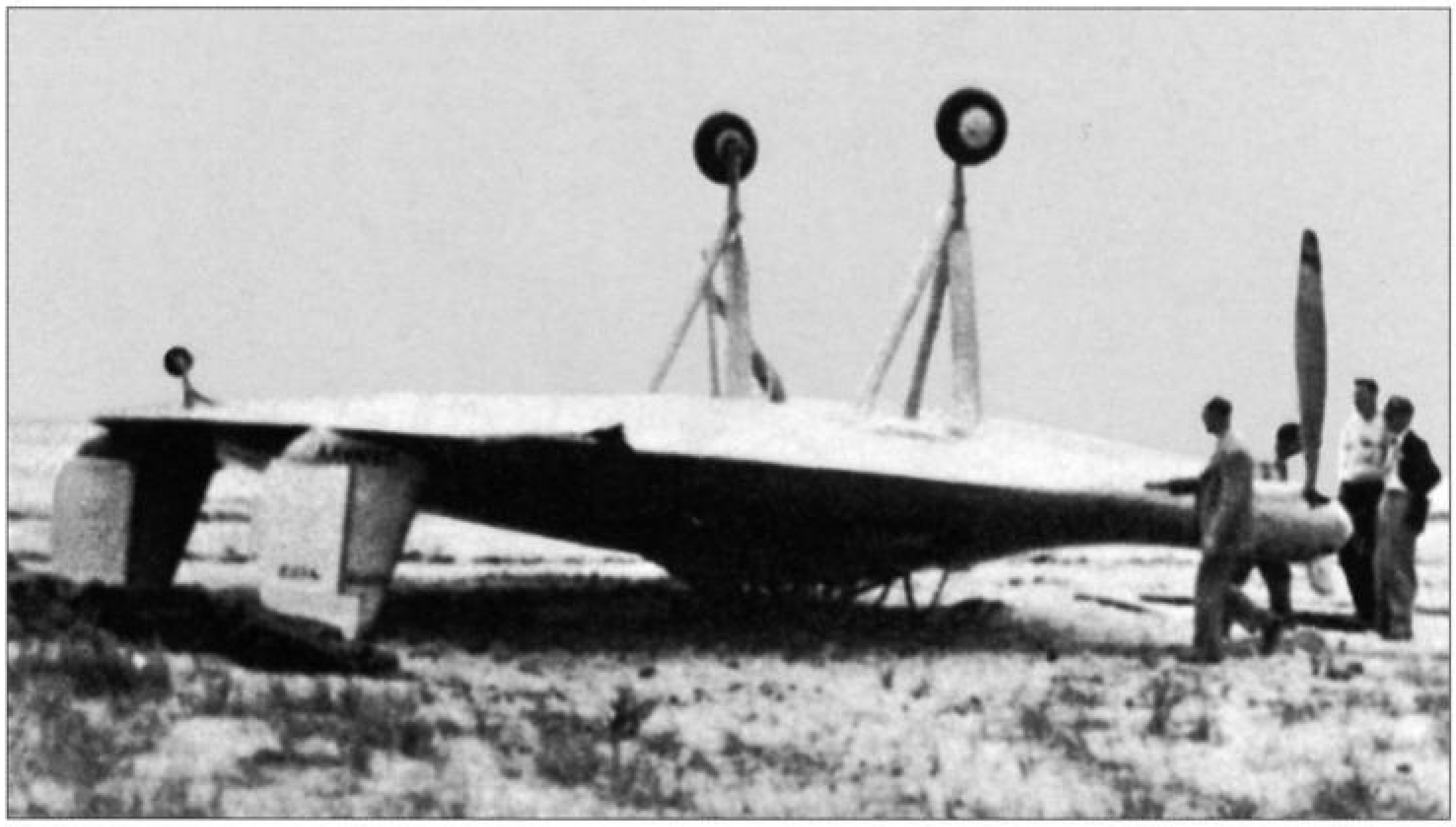
The XF5U-1 had a normal loaded weight of 16,802 lb (7,621kg), partly made possible by the extensive use of newly developed Metalite, which was a composite material formed from balsa wood sandwiched between aluminium sheets. This effective material was also used for sections of the Corsair shipboard fighter and would find its way into several later jets. When final calculations for the XF5U-1's performance were completed, the aircraft's 217-gallon (986.5 litres) fuel capacity was expected to provide a range in excess of 900 miles (1,448km).

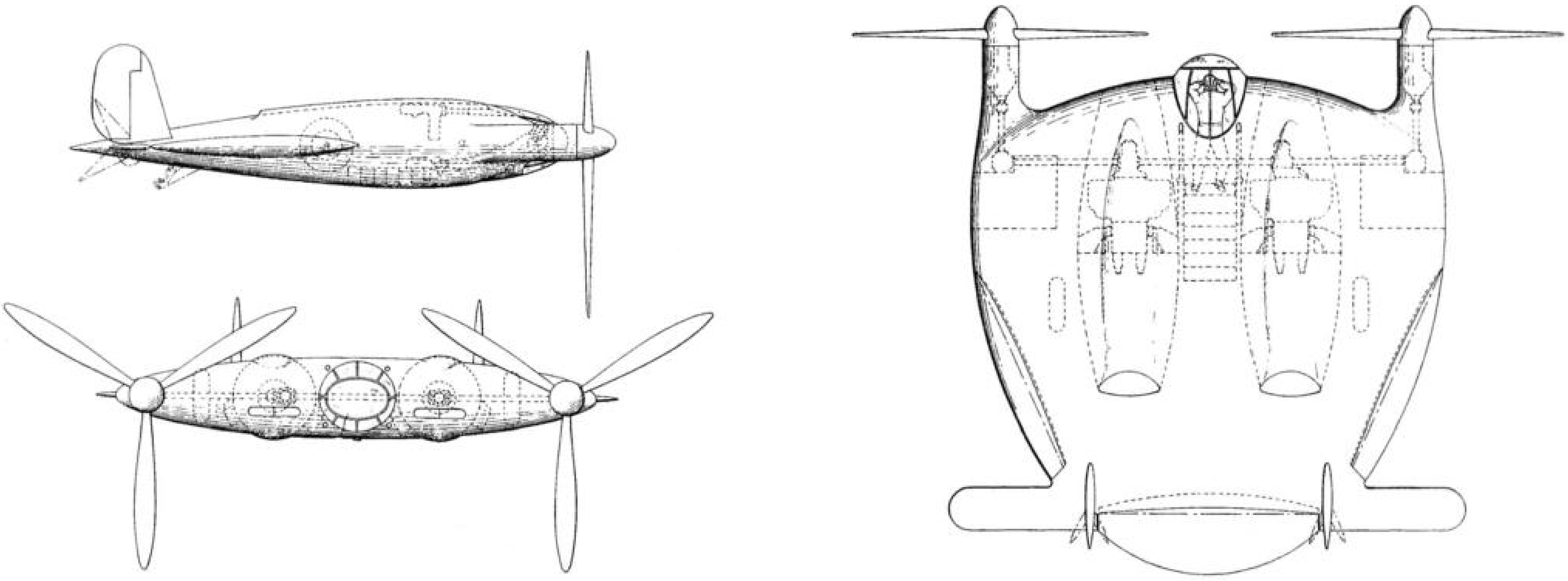
The XF5U-1 had a width of 32ft (9.75m) and an overall length of 28ft 7¼in (8.71m), but its wing area was exactly the same as the V-173. On the ground, the aircraft was angled upwards by 18° to improve lift, which was some 4° less than the V-173. Proposed armament for the production F5U-1 was initially six .50-calibre (12.7-mm) machine guns, which were later replaced by four 20mm cannons, and there were provisions to carry two 1,000 lb (453kg) bombs or additional fuel tanks.

By early 1945 taxying trials had largely been completed at the company's airfield. Nevertheless, the complex engine and gearbox layout continued to cause headaches and these, combined with what Vought described as 'accountancy problems', are said to have caused further delays in the test schedule. During August 1945, the XF5U-1's three-blade propellers had been changed to four-bladed Hamilton Standards that were used on the F4U-4 Corsair fighter. This addressed concerns about asymmetrical airflow, which stemmed directly from a vibration problem experienced with the V-173. But the change was only a half-measure and, while the new four-bladed propellers might have been satisfactory in level flight, there were serious concerns about their performance at high angles of attack.





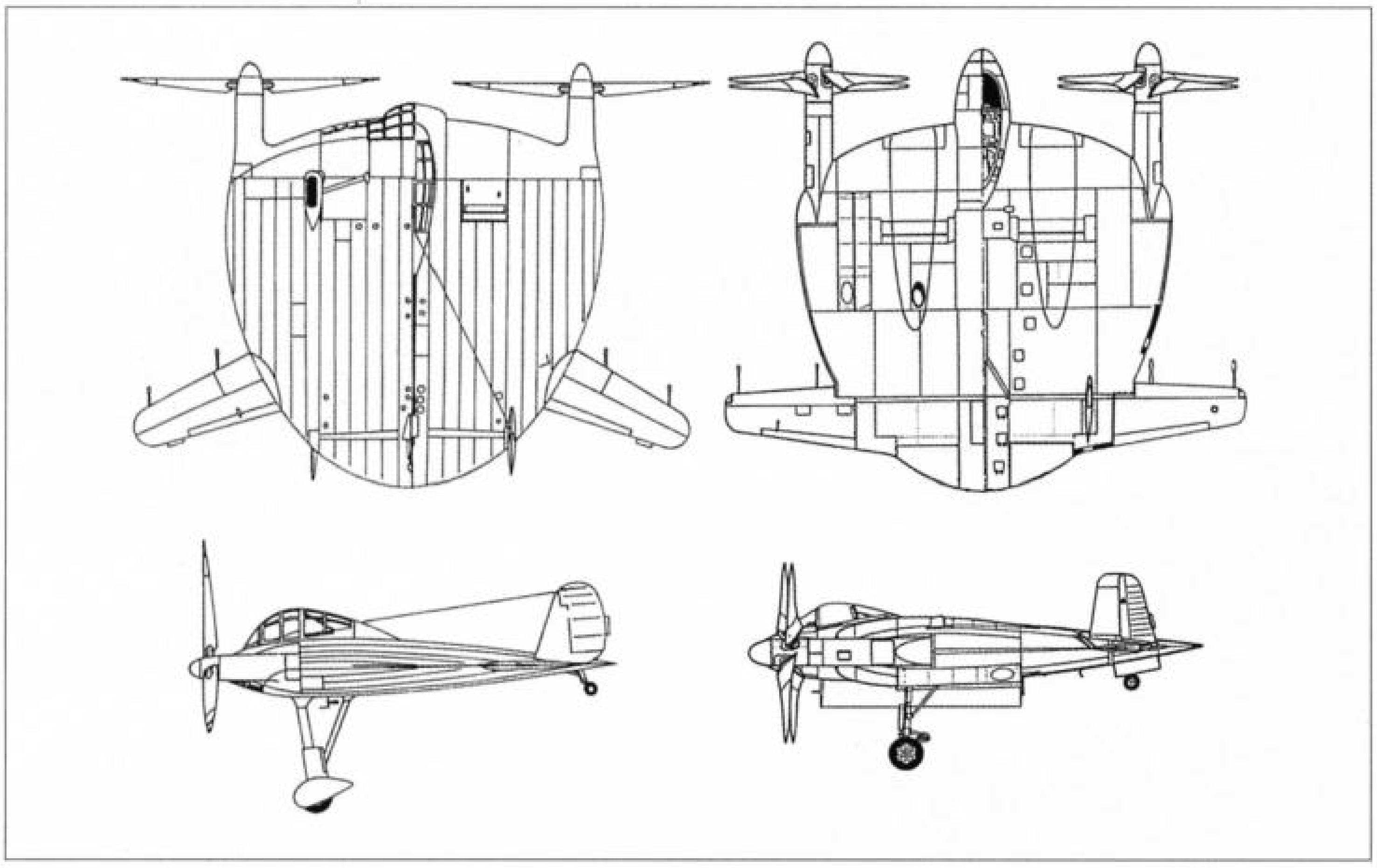


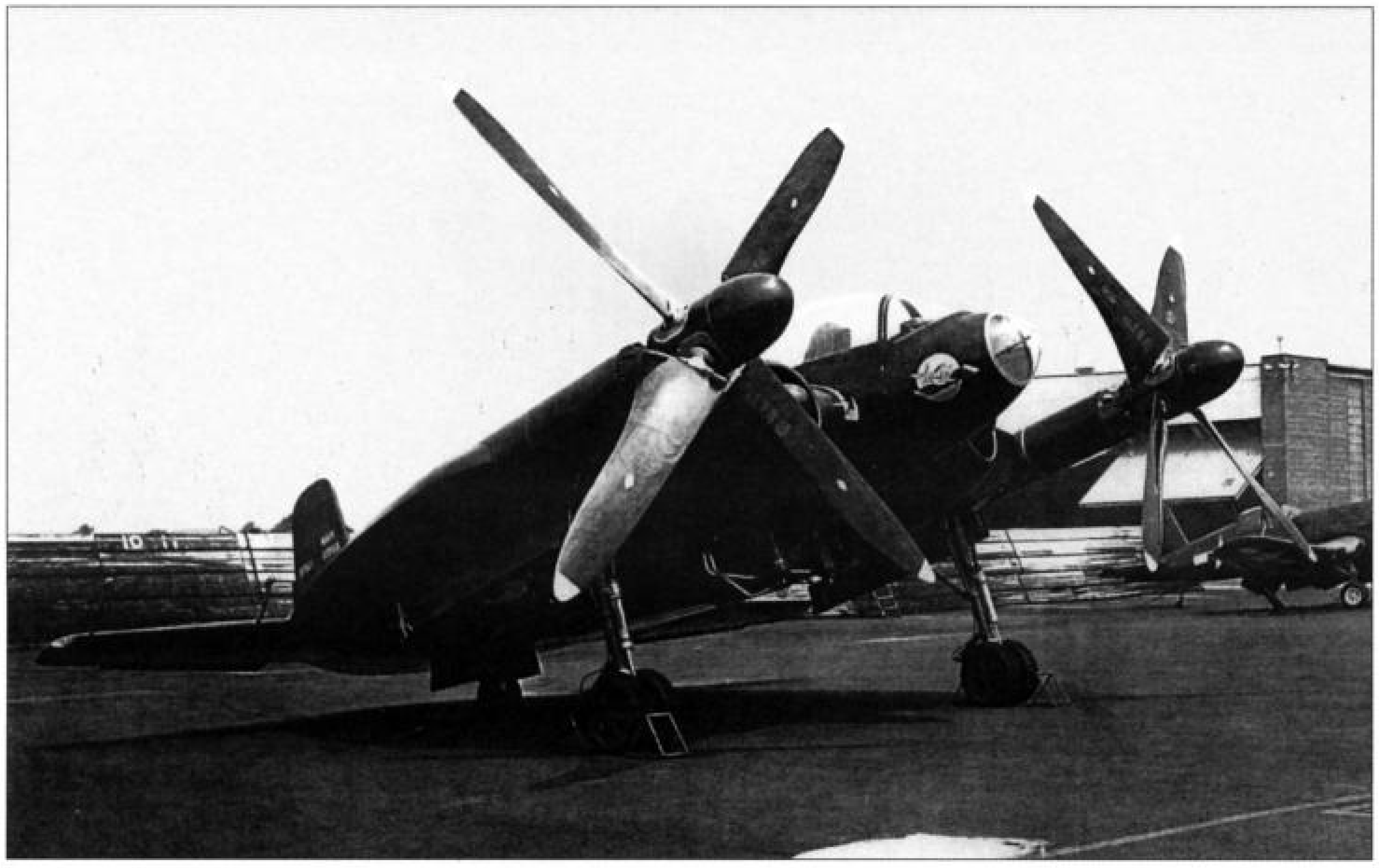


Above: **Vought VS-315. This was an intermediate concept between the V-173 and XF5U-1, produced by Charles Zimmerman. The idea of a prone cockpit layout was not adopted by the US Navy.** via Bill Rose

Left: **Comparison drawings between the Vought V-173 and XF5U-1 aircraft.** Bill Rose

Below left: **Vought XF5U-1 with 4-blade propellers.** US Navy

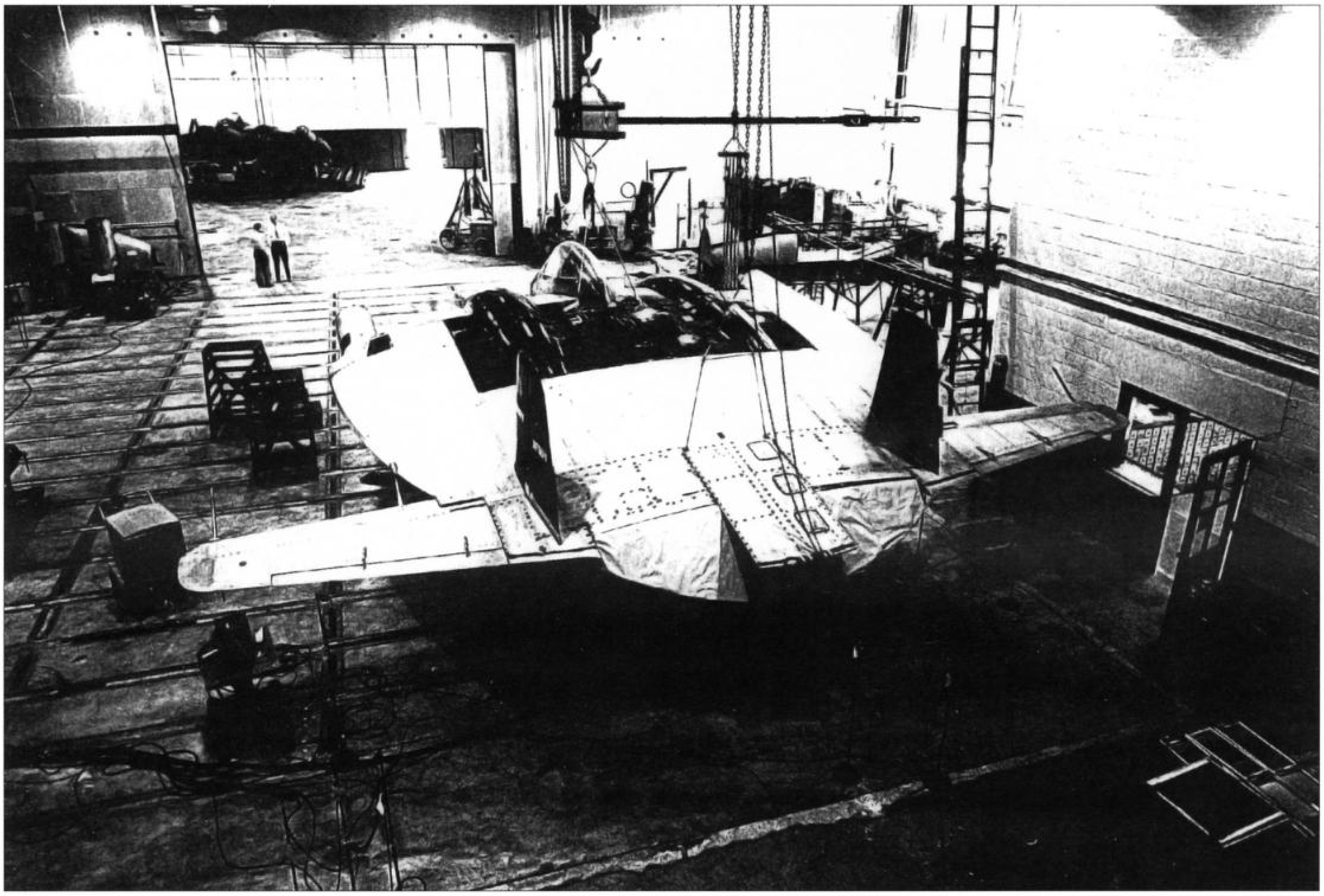




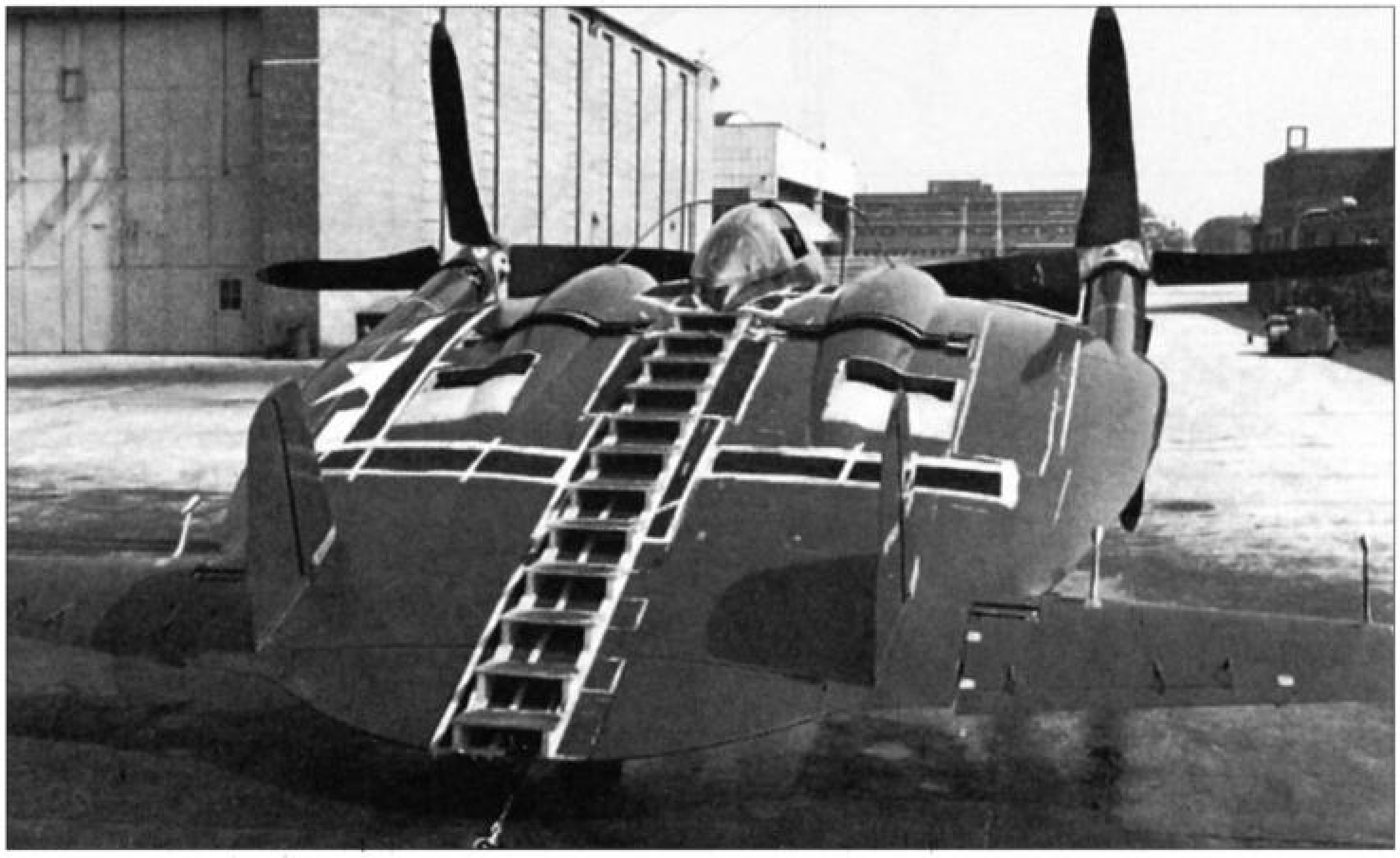
The four-bladed propellers continued to be used for engine and taxying trials, while Zimmerman took another look at an idea he had proposed in 1943, finally deciding that heavy-duty articulated flapping helicopter types were needed, with two blades mounted slightly ahead of the others. Vought's helicopter specialist Ralph Lightfoot also suggested fitting extended fairings on the outer sides of the propeller nacelles to improve aerodynamic performance, but this option was never taken up.

By late 1945, the static XF5U-1 had been destroyed during tests to determine load limits, but flights of the original V-173 continued, with the famous aviator Charles Lindbergh piloting the aircraft on at least one occasion. The XF5U-1 was scheduled to begin flight-testing in 1947 and preparations had been drawn up to ship the XF5U-1 to Muroc Field in California (now Edwards AFB) via the Panama Canal. The choice of Muroc Field remains somewhat mysterious, as it would have been much easier to conduct trials at Patuxent River Naval Air Station in Maryland, as is normally the case with new Navy aircraft.

However, the Navy had concluded that propeller-driven combat aircraft had reached their performance limits as far back as 1944



Vought XF5U-1. The second test example is visible in the rear of this picture. US Navy

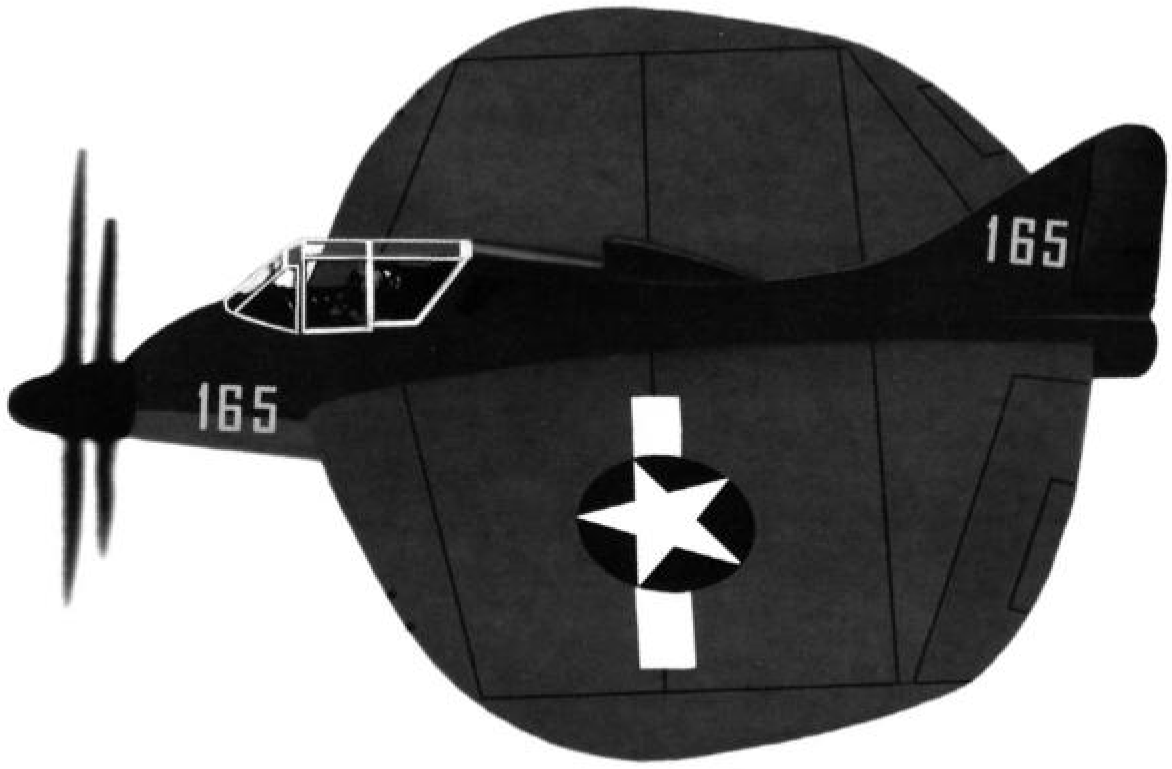


Vought XF5U-1 showing entry steps and cockpit rail. US Navy

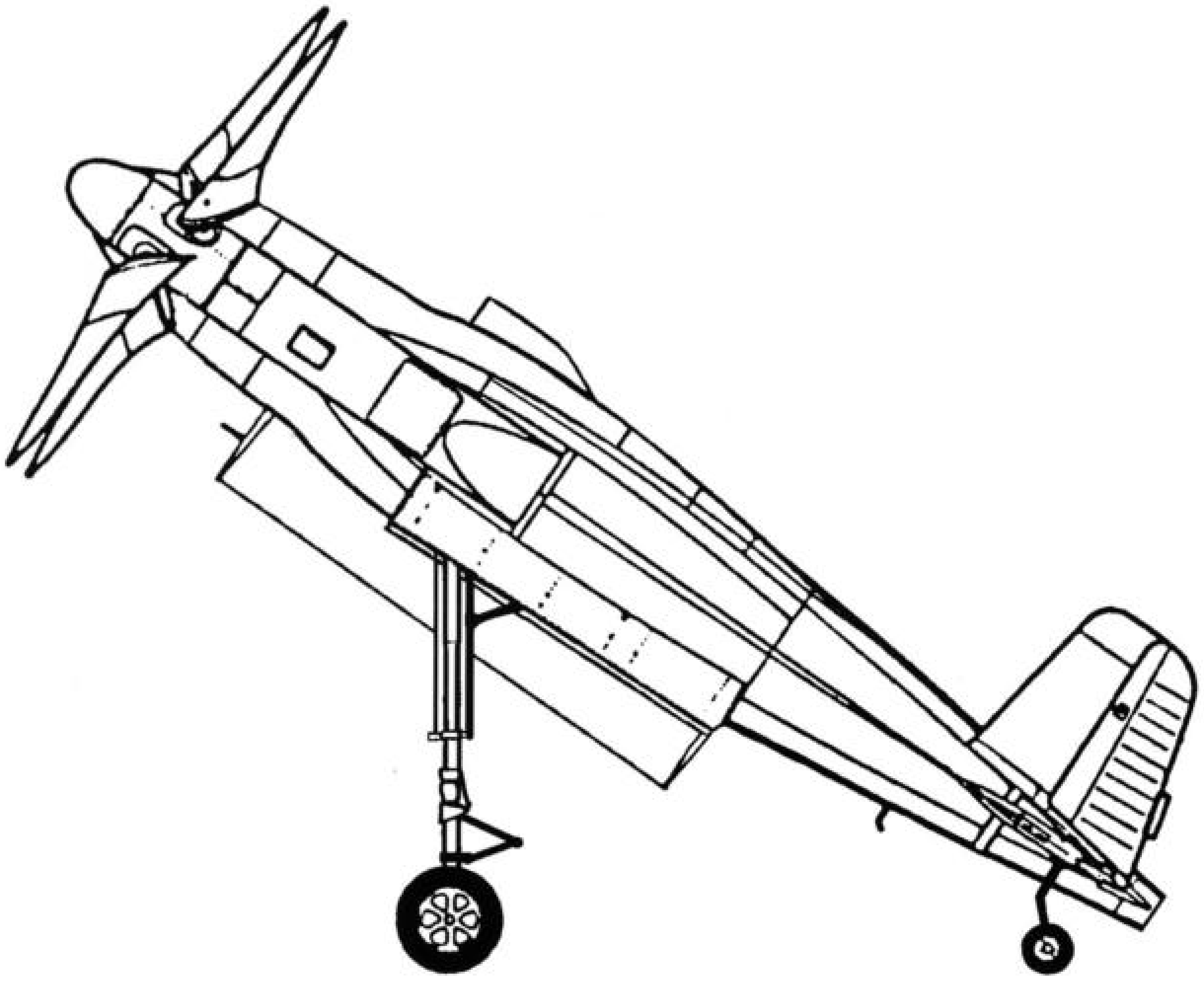
and they realised that the future lay with jets, so continuation of this project had been in doubt for several years. As a consequence, the V-173 trials were abruptly ended and the Pentagon pulled the plug on all further XF5U-1 development. Vought was in the process of relocating to Dallas. Senior company officials were preoccupied with the move and seemed to be unconcerned about the cancellation of their troublesome Skimmer project.

While the V-173 was passed to the Smithsonian, the fully completed XF5U-1 was not so lucky. On 17th March 1947, the Navy rather bizarrely instructed Vought to reduce it to scrap, despite protests from Chance Vought's senior test pilot Boone Guyton, who tried to physically prevent the wrecking crew from carrying out their assignment. Reports suggest that the XF5U-1 resisted the wrecking ball for some time, but the aircraft was finally smashed to pieces and ended up in a massive 40ft (12m) high pile of metal scrap, which included jigs and special tooling equipment from the plant.

Within the wreckage was $6,000 worth of silver that had been used for parts in the gearboxes ($6,000 was a small fortune in those days!). Nobody had remembered to retain this precious metal and, when the mistake was realised, a number of staff and security personnel were hastily assigned to search the scrap heap but the silver proved impossible to locate and their search was finally abandoned. However, the local scrap dealer who hauled away the wreckage eventually found the silver and this attracted FBI interest when he came



Left: **Boeing B.390, a wartime carrier-based STOL design, competing against the XF5U-1. Although less complex and probably more reliable, the B.390 would not have shared the performance capabilities of the XF5U-1.** Bill Rose



Below left: **Appearance of a third-generation Vought Skimmer powered by a gas turbine engine. Capable of VTOL operation, the pilot would fly the aircraft from a prone position.** Bill Rose

to sell it. Vought were finally obliged to reach a financial settlement with the Navy for the cost of the silver and forced to confirm the dealer's legal right to profit from their mistake.

For many years, stories have circulated that scrapping the XF5U-1 was a cover story and the aircraft was actually shipped via the Panama Canal to Muroc Field where it crashed during an early test flight. While this is an intriguing idea, there is absolutely no evidence to support the theory and it can be ruled out.

Boeing's Little-Known Rival

In early 1943, just a few months after Vought had been given the go-ahead to build two XF5U-1s, the US Navy approached Boeing to design a rival single-engined STOL shipboard fighter with a broadly similar capability. Although not usually associated with fighters, Boeing's Seattle design office came up with a series of intriguing proposals for a carrier-based combat aircraft with an elliptical planform.

Their project would start with the construction of a one-man, low-speed proof-of-concept demonstrator called the Boeing B.396, which was expected to perform like the Vought V-173. The B.396 would be approximately the same size as the proposed combat aircraft, but simplified in design and fitted with a low-power engine that was sufficient to study its low-speed handling characteristics. The designation of this proposal suggests that the B.396 was conceived once some initial work was completed to establish the viability of a full-sized fighter aircraft.

After a period of testing, the first prototype semi-disc shaped, single-seat Boeing B.390 fighter would succeed the B.396. It would be powered by a single 3,500hp (2,610kW) Pratt & Whitney R-4360 28-cylinder air-cooled radial engine, driving a single counter-rotating assembly that used three-bladed propeller assemblies. This design was mechanically simpler than the complex power transmission and propeller blade arrangement used by the Vought XF5U-1 and the general reliability was accepted as being significantly better.

Although the Boeing B.390 was expected to provide exceptional STOL performance, its capability would never have matched the fully developed Vought F5U, which was designed to hover in a vertical attitude. Boeing suggested that the B.390 prototype would be capable of about 425mph (683km/h) and the production version would be fitted with a two-stage supercharger, providing a top speed of about 452mph (757km/h). One rather unusual feature was the ducting of the engine exhaust to the rear of the fuselage, which was expected to provide a small amount of added jet thrust.

Designated as the Boeing B.391, the production fighter would have been armed with four 20mm cannons and capable of carrying a modest bomb load. Needless to say, this Boeing shipboard fighter never progressed beyond being a paperwork study. It seems certain that this unusual aircraft could have been built, tested and put into production; but by the end of World War Two it had been filed away and forgotten.

Advanced Pancakes

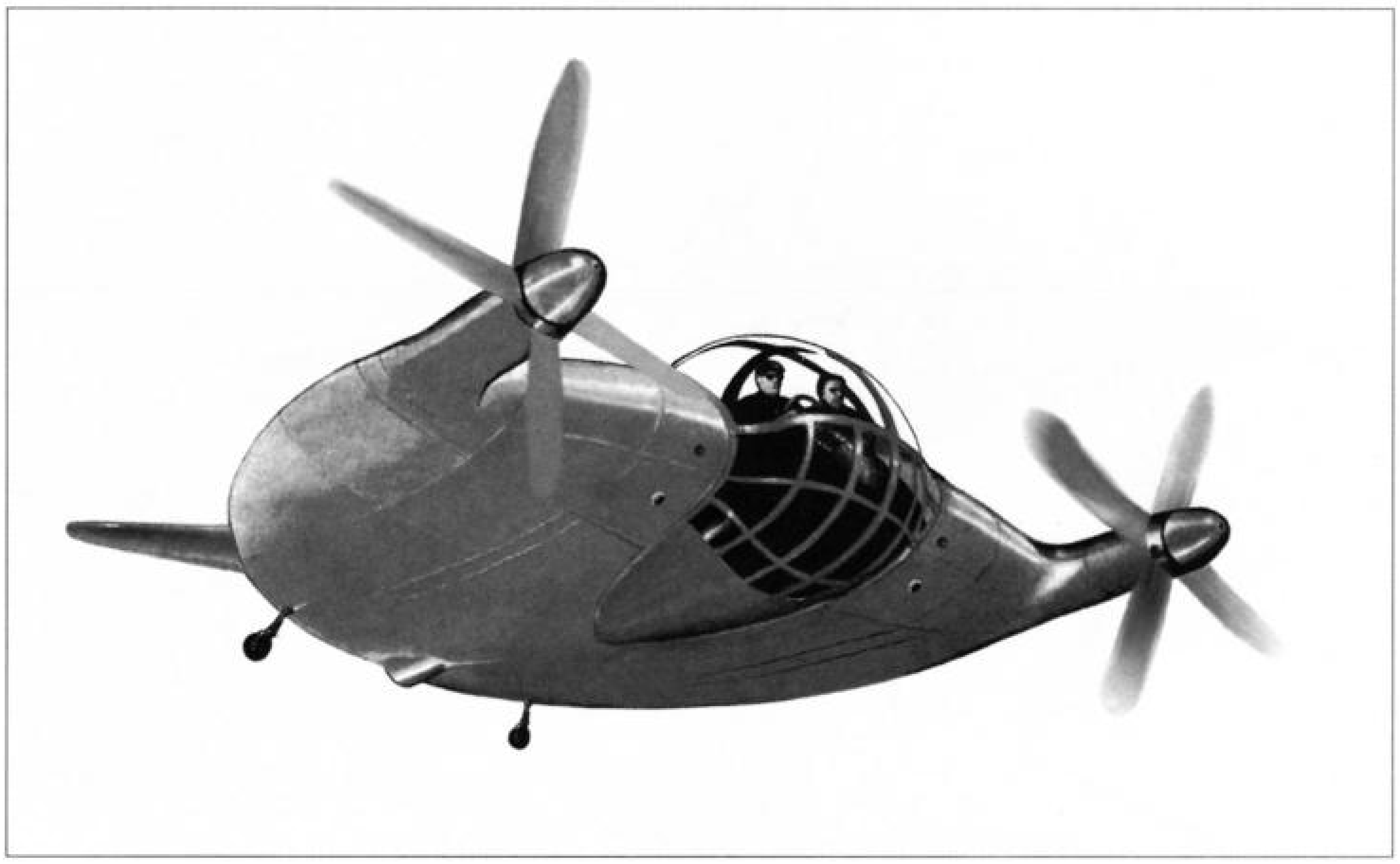
Thomas Clair Smith, who eventually became Vice President of the Woodstream Corporation, joined Vought in 1946 after graduating from Penn State University with a degree in mechanical engineering. Almost immediately, he was assigned to testing components that included aircraft arrester hooks and exploring the bonding abilities of lightweight composites such as Metalite. After clearance by the FBI, Smith was moved to classified development

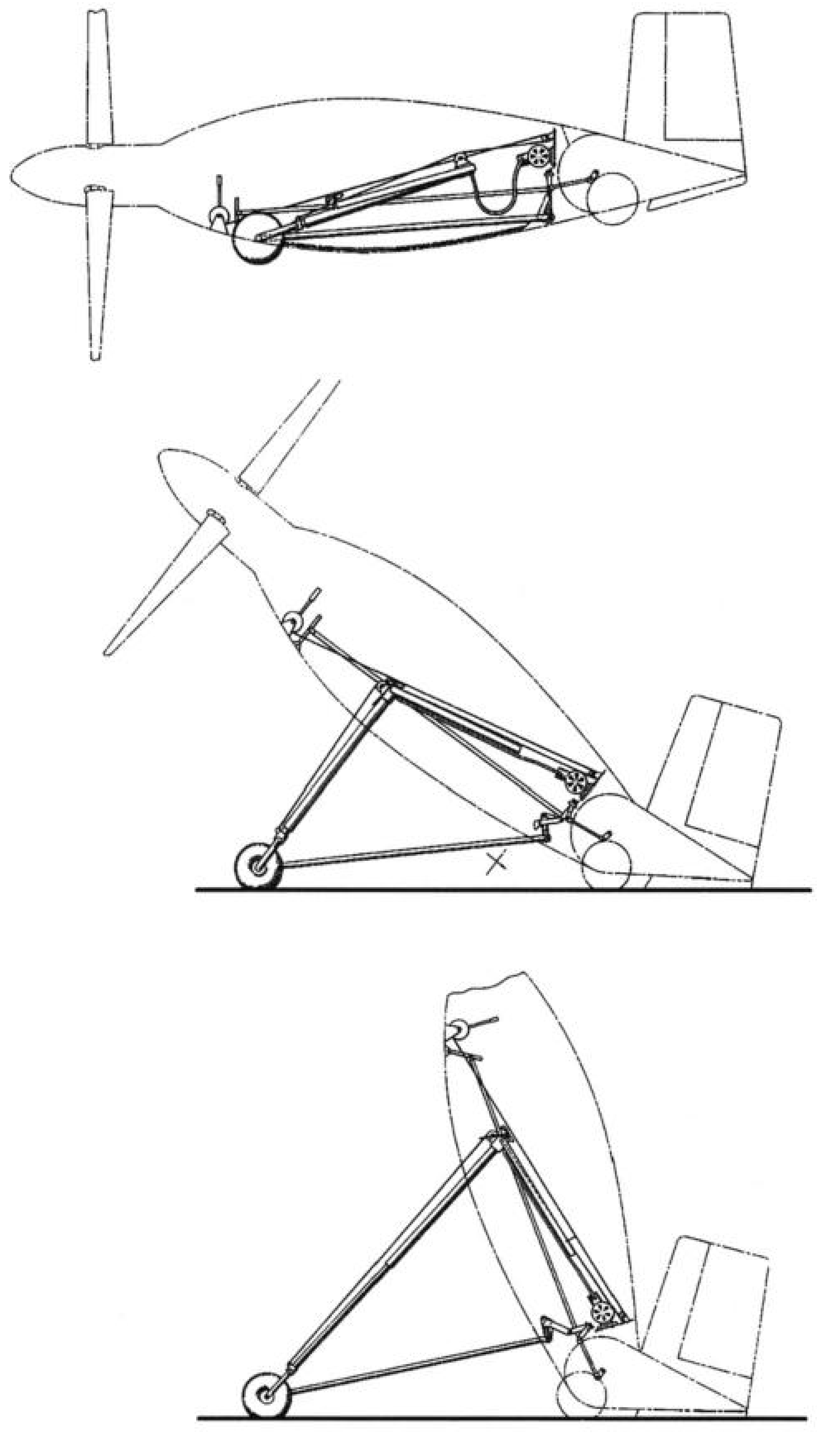
Right: **This artwork based on several sources shows a postwar Turbo-Skimmer intended as multi-role VTOL utility aircraft.** Bill Rose

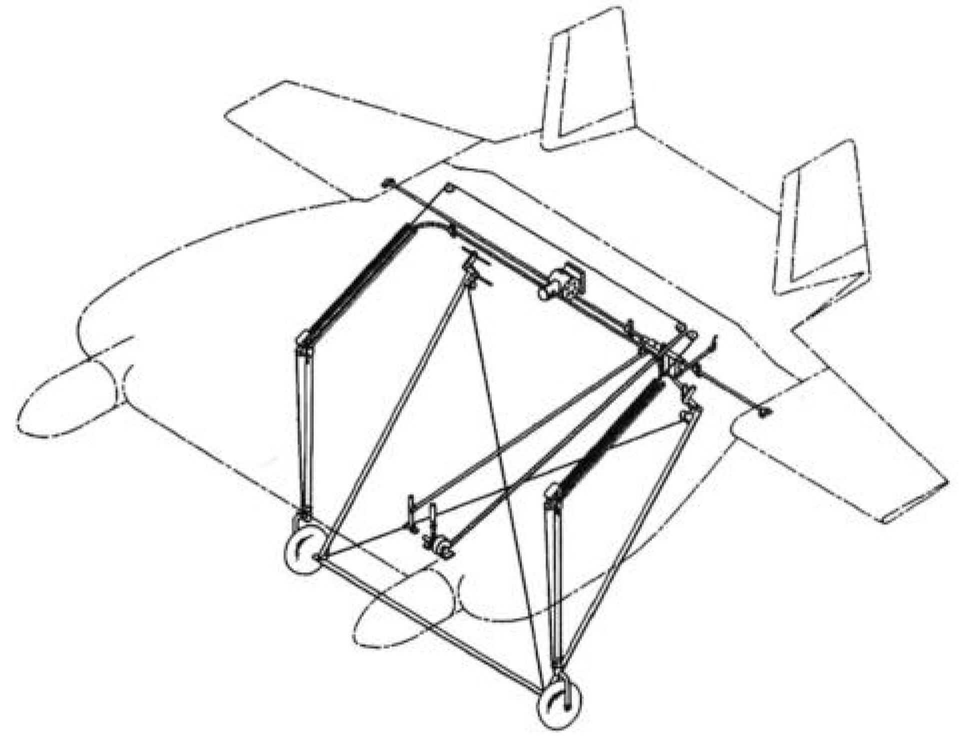
Below left: **By folding the tail assembly to facilitate an upright position, Charles Zimmerman intended to allow a more powerful version of the Skimmer to achieve full VTOL performance.** US Patent Office

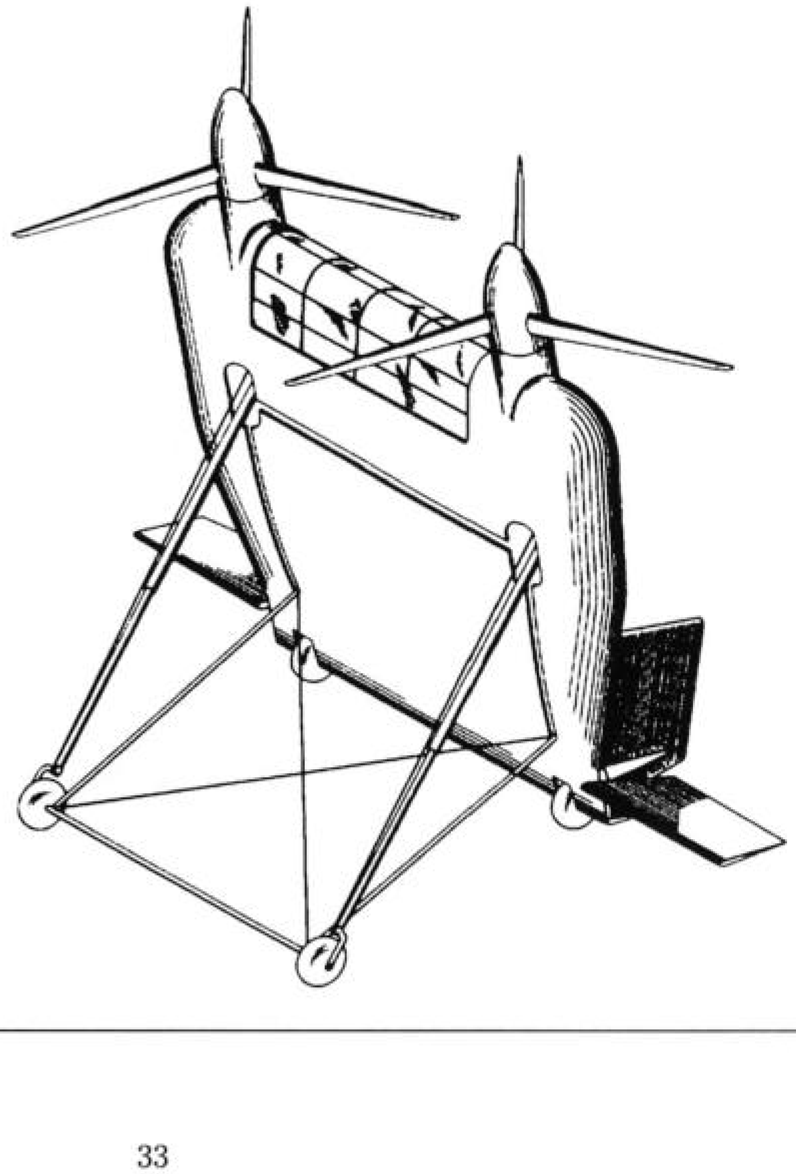
Below right: **A complex undercarriage design produced for an advanced Skimmer by Zimmerman, which would allow upright positioning in conjunction with a folding tail. This would be used for VTOL operations, while also allowing conventional runway take-offs and landings.** US Patent Office

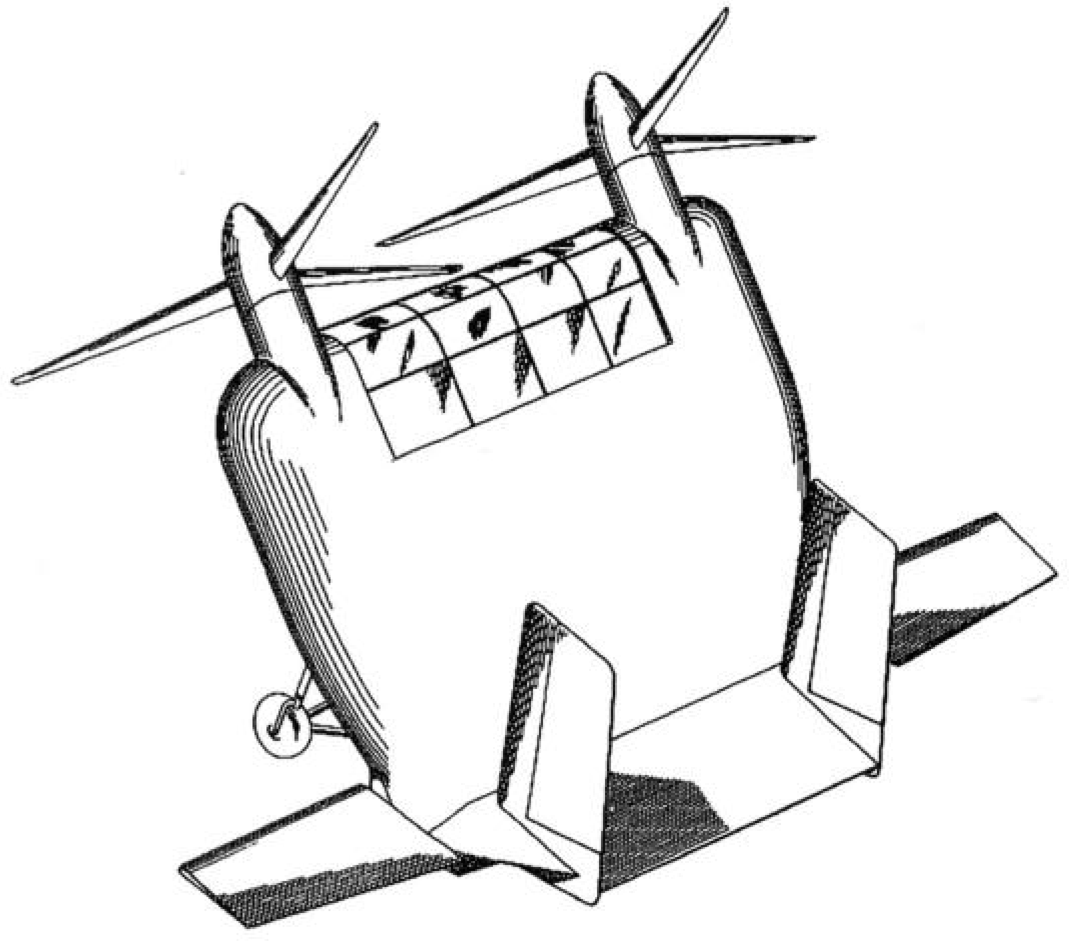
Bottom right: **Revised postwar undercarriage design by Zimmerman for an articulated tail to facilitate easier VTOL operation with a Skimmer-type design.** US Patent Office

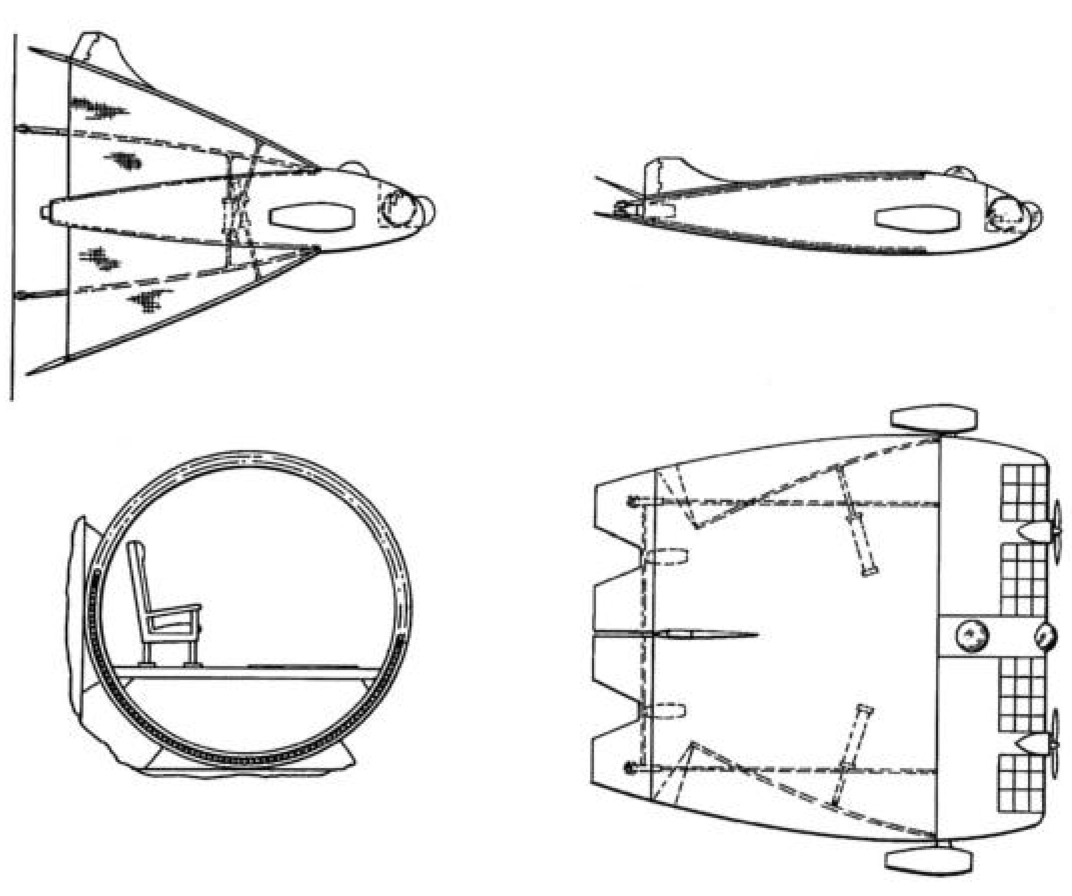












Above left: **Postwar design by Zimmerman for an articulated tail to facilitate easier VTOL operation.** US Patent Office

Above right: **Design study by John Sullivan in 1954 to produce a more advanced VTOL version of the Skimmer using a complex landing gear system, a rotating cockpit and additional jet power.** via Bill Rose

work, which included the evaluation of new materials for use at high altitudes. These would find their way into several prototypes under development by Vought for the US Navy.

Although security at Vought's plant was extremely tight and R&D was highly compartmentalised, Smith was eventually shown the latest partly-completed secret jet fighter (thought to have been the XF7U-1 Cutlass) and a totally unacknowledged VTOL version of the Skimmer. According to Smith, this aircraft was flown from a prone position. It used a gas turbine engine to drive the propellers and was supported on very long forward undercarriage legs. 'Did the aircraft fly?' said Smith, pre-empting an obvious question. 'You bet', he continued. 'I saw it take-off, hover and land. It was only tested at night. They'd get it off the ground and it would disappear into the darkness.' Apparently, there were soon plenty of local stories in circulation about unidentified objects seen in the night sky around the company's airfield. 'Those of us that worked on the project', said Smith, 'got a chuckle about these reports, since we knew what they had seen'.

Smith went on to explain that he left Vought in 1947 when the company moved to Texas and he believes the prototype was taken there. Unfortunately, there are no documents available to support Smith's account and this intriguing story remains uncorroborated at the present time. Nevertheless, there were at least two alternative layouts for the proposed third-generation military turboprop Skimmer, and the first was very similar to Smith's description. This design featured a centrally-positioned axial-flow gas turbine that was shaft-coupled to each propeller. Exhaust gases were vented through a port in the tail and this led to the use of two tailwheels rather than one.

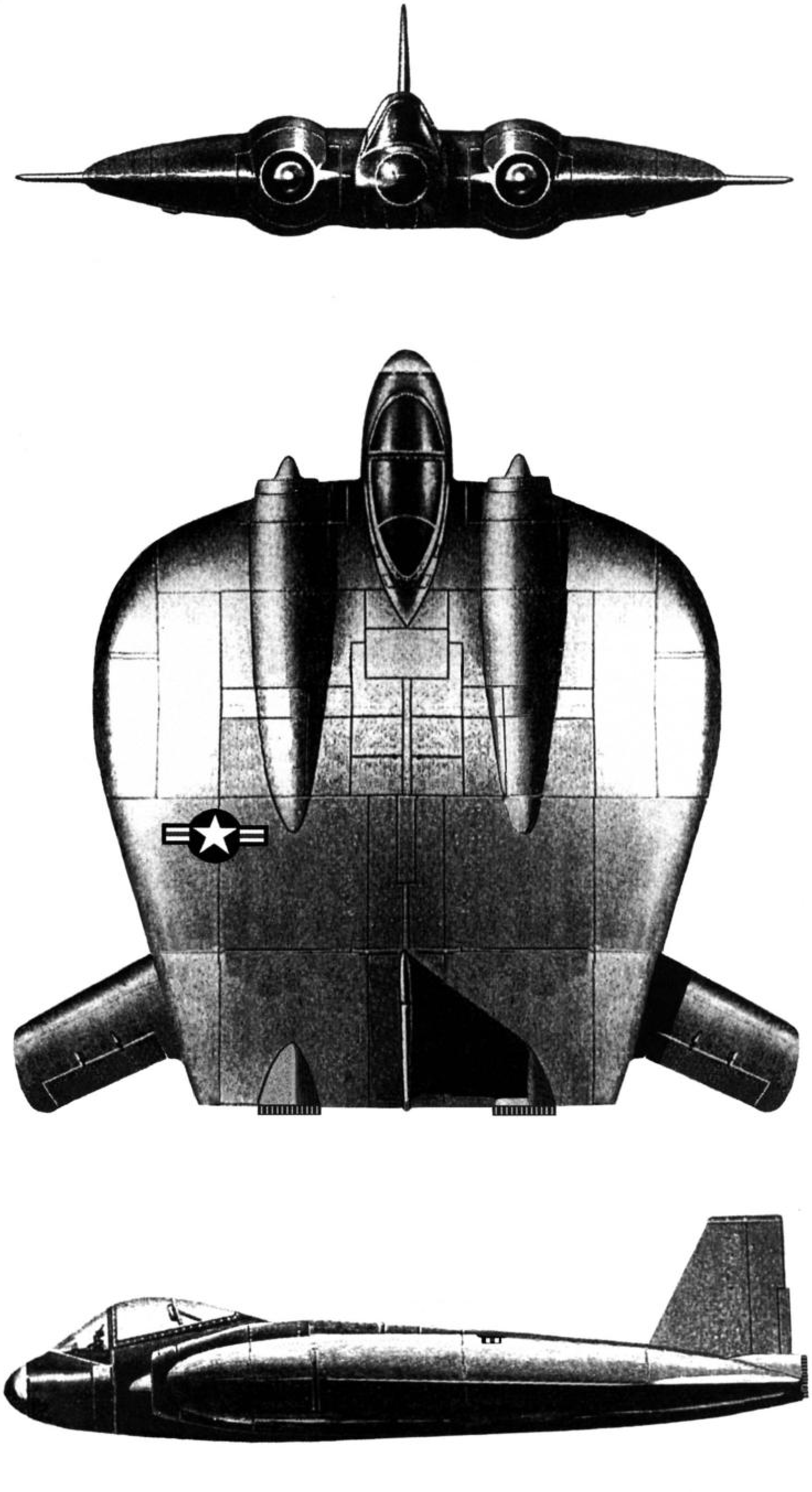
The second design appears to have involved a straightforward gas turbine substitution for both of the air-cooled radial engines, which were shaft-coupled to each propeller. This option was briefly discussed in a US Navy aviation document from October 1946, which suggested a VTOL capability and better level-flight performance than the XF5U-1.

The first illustrations of VTOL Turbo-Skimmer designs show a complicated undercarriage system, with two fully retractable forward struts that provided a maximum elevation of around 35°. These double-action stilted legs would provide VTOL in the fully raised position, or a rolling take-off when the legs were partly retracted and the aircraft was lowered. Zimmerman produced a number of increasingly complex designs for the Skimmer's undercarriage, with the most complicated arrangement allowing the aircraft to sit in an almost upright position. This was made possible by re-designing the rear of the aircraft to act as a flap that would swing forward when on the ground. Perhaps it would have worked, but adding this much extra complexity to an already troubled design would not have been popular with most engineers.

Some documents indicate that Vought proposed an advanced turboprop Skimmer with a VTOL capability for a joint US Navy-USAAF design study called Project Hummingbird, which began in April 1947. This may have been the case, but the only designs to reach development were tail-sitters produced by Ryan, Lockheed and Convair.

After the War, Zimmerman revived and updated his Aeromobile concept and hoped to build a civilian version of the VTOL Turbo Skimmer, which was capable of carrying a pilot and two or three passengers in a swivelling cockpit. Perhaps the Skimmer could have been developed into a useful utility aircraft if adequate funding had been made available for further R&D, but reliability of the power transmission system left much to be desired and the behaviour of the articulated propellers was poorly understood.

On 9th July 1947, an unidentified heel-shaped aircraft with the same distinctive sound as an Allison-engined P-80 Shooting Star passed over Phoenix, Arizona and widespread sightings were reported in the Arizona Republic newspaper. Witnesses said that the aircraft flew in from the west and later returned in the same direction, towards California. There have been persistent rumours that at least one experimental jet-powered disc-shaped aircraft was built for the US Navy during this period, but no documentation can be found to validate the suggestion. It is conceivable that a black-domain jet-powered aircraft along the lines of a fourth generation Skimmer was completed as a one-off STOL prototype and perhaps the details will eventually surface, along with those of Smith's secret nocturnal prototype.



Hypothetical appearance of a secret postwar turbojet-powered STOL Skimmer. Although no documentation has surfaced to suggest such an aircraft existed, there have been various suggestions that propellers could have been replaced by jet engines. Bill Rose

One final attempt to refine the Skimmer was made by a Norfolk, Virginia-based aeronautical designer called John J Sullivan, who produced plans in 1954 for a new aircraft that evolved from the earlier work undertaken by Zimmerman. He incorporated a complex system of folding supports that allowed the aircraft to take off and land in a vertical position, with a cylindrical rotating cockpit that would move through 90° during transition to level flight. The size of this design was somewhat larger than the Skimmer, with various propulsion options discussed that included propellers and jet engines in pods. Drawings show a complex design that would have represented a serious challenge to most engineers and Sullivan's study never progressed beyond the paperwork stage.

When Vought relocated to Texas in 1947, Zimmerman rejoined NACA at Langley, where he resumed his work on wind tunnel testing and began to experiment with simple compact VTOL platforms that could be flown with comparative ease by an average person. A small demonstrator called Flying Shoes was completed and this used a fan lift arrangement, with the pilot standing upright above the platform and controlling its movement by leaning his body in the desired direction of flight. Zimmerman continued to improve the design and, during 1948, Stanley Hiller of Hiller Helicopters purchased the rights to the Flying Shoes.

Zimmerman then started work on a small platform called the Jet Board, which was powered by compressed air. This was followed by a rotor-driven version called Whirligig, which flew on 21st October 1953. Hiller and De Lackner Helicopters pursued personal flying platforms based on Zimmerman's research, but serious technical problems and safety issues prevented these ideas from progressing beyond prototypes.

In 1952, Zimmerman became a member of the Brown Hypersonic Group that studied proposals for trans-atmospheric vehicles, which finally led to the North American X-15 rocketplane. Six years later Zimmerman joined NACA's Space Task Group, which produced the basic specification for the Mercury space capsule and planned the Apollo project. In 1962 he became NASA's Director of Aeronautics, remaining in this post until 1967 when he retired. Zimmerman died on 5th May 1996.

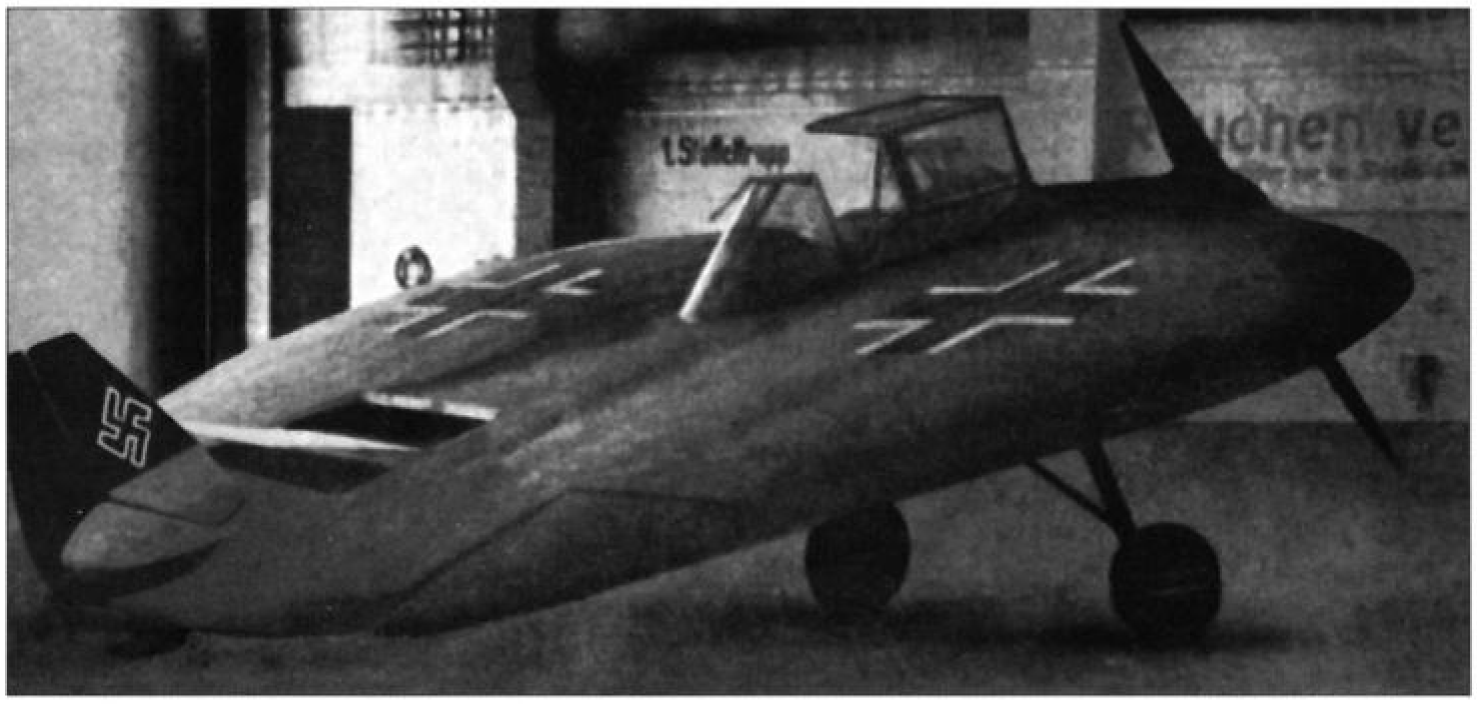
German Wartime Flying Discs

The following chapter is a serious attempt to outline everything currently known about the circular winged aircraft that were developed by German engineers and scientists during World War Two. Regrettably, there are many gaps in the historical detail and matters have not been helped by the vast amount of complete nonsense, either in print or floating around the Internet, which has often interfered with serious research.

There are four separate German programmes that qualify for inclusion in a book dealing with the history of flying saucers and, while one remains very doubtful, the topic still merits discussion. The most straightforward World War Two flying disc development was Arthur Sack's propeller-driven, single-engined AS-6 aircraft. Although AS-6 had some interesting features, this design was seriously flawed from the outset and the aircraft only managed a few brief lift-offs at Brandis Airfield.

Heinkel and BMW appear to have been responsible for undertaking the second project in Czechoslovakia and almost everything currently known can be found in this chapter. Unfortunately, the details of this obscure project have become grossly distorted during the course of time, but sufficient evidence exists in scattered material to validate its existence. The third VTOL saucer project was initially undertaken by Focke Achgelis and reached the wind tunnel testing stage. This design proved extremely influential in post-war American design thinking and was taken up by Goodyear who saw the potential for a new carrier-based aircraft.

As hostilities intensified, German engineers and scientists turned their attention to air defence measures and there is a widely held belief that a rather mysterious disc-shaped missile called a Foo Fighter was deployed towards the end of the war (the name was given by Allied aircrews). Finally, the Horten Brothers have been allowed some space because they operated at the cutting edge of German aeronautical development during World War Two and this eventually led to US military concerns that they had become involved with the secret construction of flying saucers.



Arthur Sack's AS-6 V-1 circular-winged experimental aircraft at Brandis during World War Two. Several heavily re-touched versions of this image are in circulation, which seem to have been altered to enhance the aircraft's circular appearance. via Bill Rose

Left: **Air Minister Ernst Udet, who encouraged development of Sack's AS6 V-1.** via Bill Rose

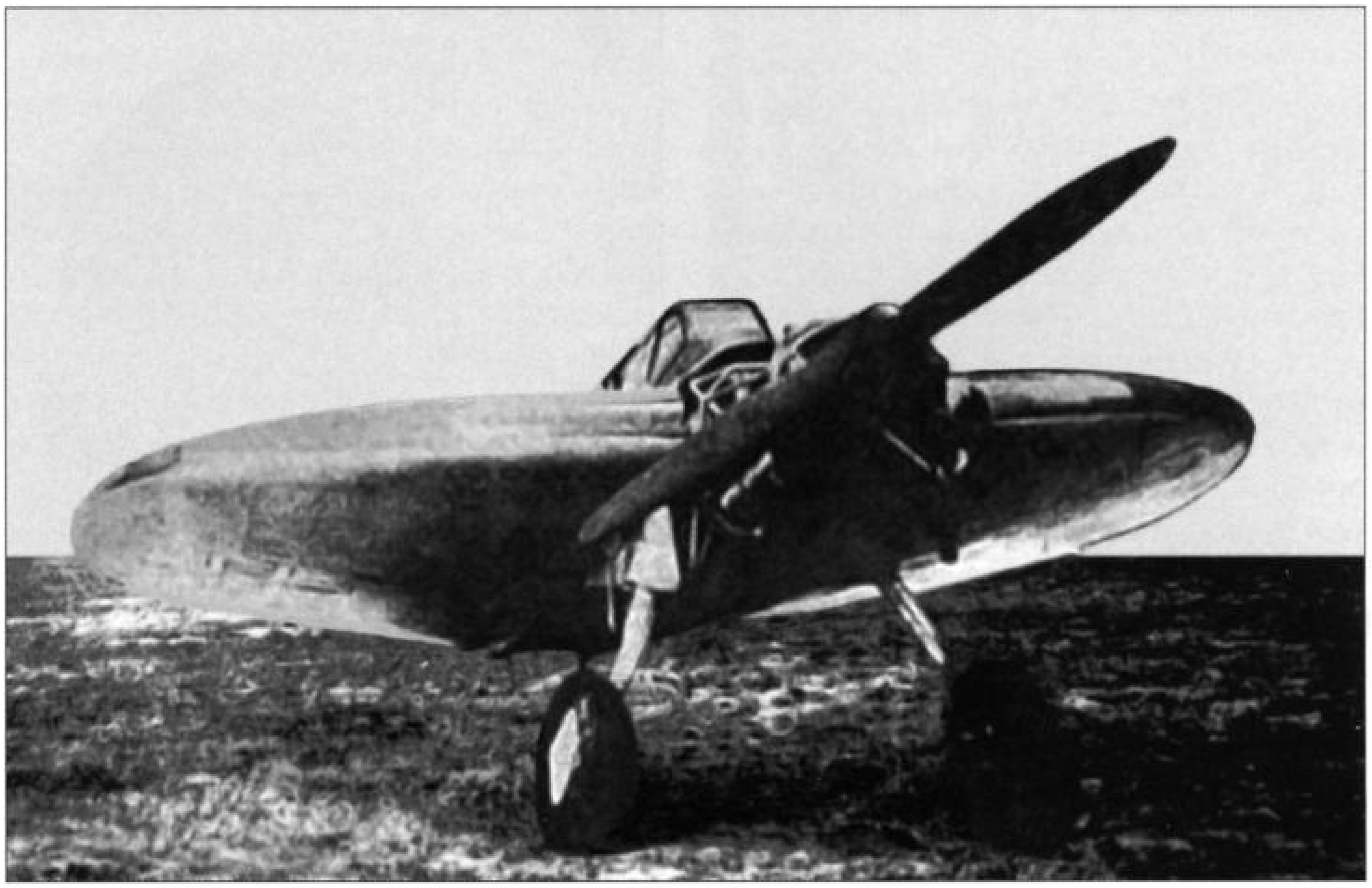
Above: **Legendary aerodynamicist Alexander Lippisch, who is said to have briefly assisted Sack with the design of AS-6 V-1.** via Bill Rose

Germany's Wartime Low-Tech Flying Saucer

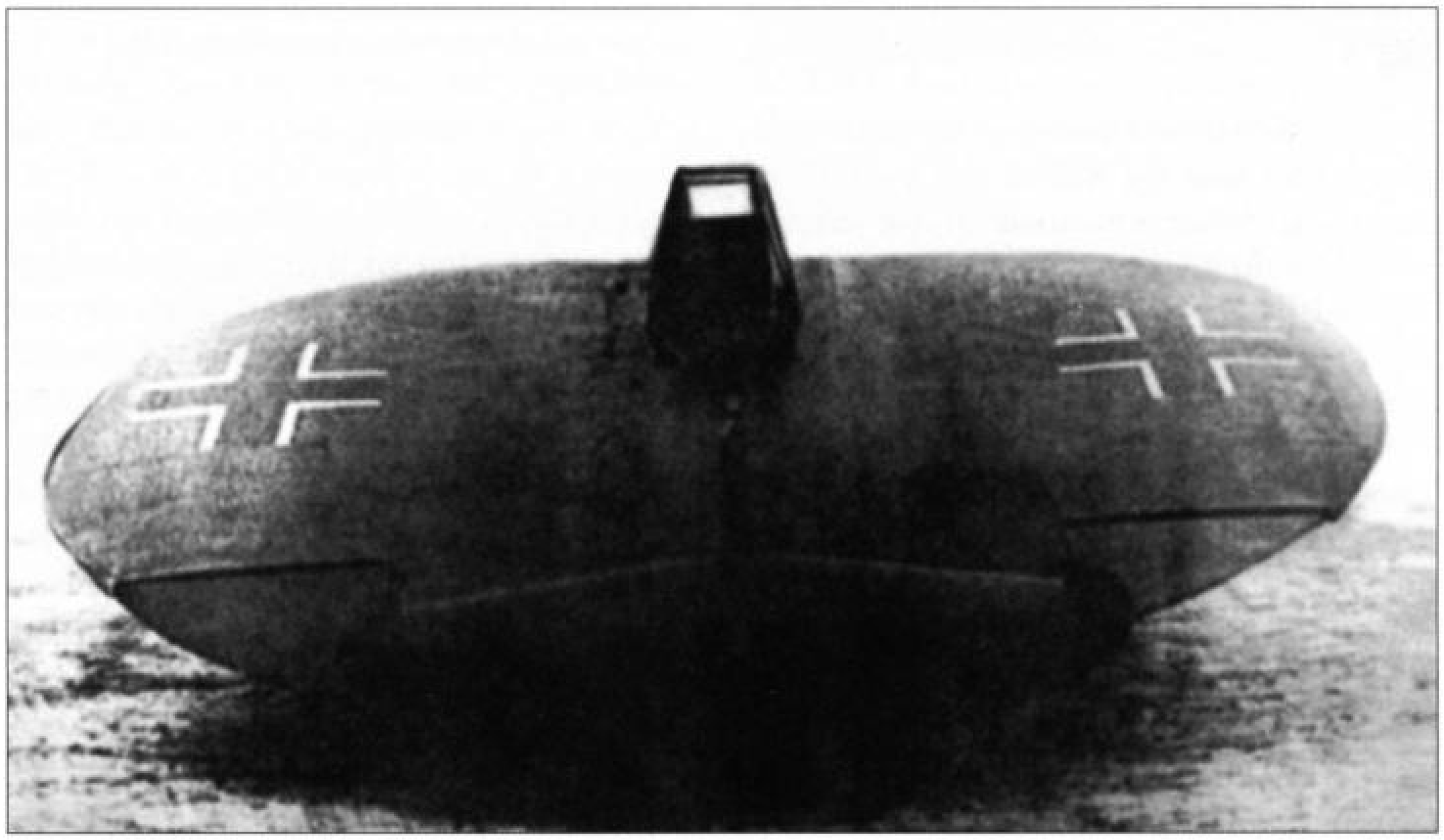
Until a series of black and white photographs surfaced which proved its existence, little was known about a small wartime German circular-winged monoplane that was often dismissed as a myth. The design of this aircraft can be attributed to Arthur Sack (1900-1964), a pre-war model plane enthusiast who lived in the Leipzig area.

During the first National Contest of Aero Models with Combustion Engines, which took place at Leipzig-Mockau on 27th and 28th June 1939, Sack demonstrated his small AS-1 circular-winged design. AS-1 had a reported length of about 4ft 1in (125.0cm),

Poor quality photograph showing the front of the experimental AS-6 V-1 circular-winged, two-blade propeller driven aircraft at Brandis Airfield.
via Bill Rose



This view shows the circular shape of the AS-6 V-1 circular-winged experimental aircraft, which was badly hampered by poor assembly and the use of many scrap components. via Bill Rose



weighed 9.9 lb (4.49kg), and used a propeller measuring 23½in (59.7cm) in diameter. Unfortunately, problems arose with the AS-1's small Kratmo-30 engine that prevented a powered flight from taking place, and so it was necessary to make several launches by hand. However, Air Minister Ernst Udet was present at the meeting and he was sufficiently impressed with Sack's concept to encourage further development.

Why Sack originally decided to construct a circular-winged aircraft is unclear, although he may have seen the STOL designs that were built in America, which encouraged him to utilise similar principles. Supported by a small amount of Reichsluftfahrtministerium (RLM: German Air Ministry) funding, Sack spent the next three years refining his design and he is thought to have received some guidance from the famous aeronautical scientist Dr Alexander Lippisch.

After completing three further small model aircraft, Sack built an ultra-lightweight, single-engined, circular-winged model with an overall length of 5ft (1.5m), which he called the AS-5. The model flew in 1943 and, as a result of this, the RLM decided to commission a full-size piloted prototype, which not surprisingly was called AS-6 Versuchs 1 (Versuchs – Experimental, or Version One). Mitteldeutsche Metallwerke (who designed and built assault gliders in association with Gothaer Waggonfabrik) were contracted to assemble the basic AS-6 V1 airframe in the autumn of 1943. When the work was completed in early 1944 the airframe was passed to Luftwaffe engineers at Brandis airfield, who installed the final components.

AS-6 V-1 was largely built from wood, with a fabric covering, and it utilised many components salvaged from various wrecked Messerschmitt aircraft. The cockpit canopy, pilot's seat and instruments came from a Bf 109B fighter, while the 240hp (179kW) Argus As 10C-3 engine was retrieved from a scrap Bf 108 Taifun utility aircraft. This was fitted with a two-blade wooden propeller. The undercarriage originally belonged to a Bf 109B fighter and it was attached to the airframe in a fixed non-retractable form. A small skid appears to have been initially fitted under the tail of the aircraft and this may have been replaced with a wheel. AS-6 V1 was a very compact design with a length of 21ft (6.4m) and an overall span of 16ft 4¾in (5m); the aircraft's gross weight was approximately 1,984 lb (900kg).

During February 1944 taxying trials were carried out at Brandis by Rolf Baltabol, the chief pilot for ATG (a Junkers subcontractor). He immediately discovered that the aircraft was poorly constructed and the rudder needed considerable modification. Five short lift-offs followed using the main 4,100ft (1.25km) runway and these tests highlighted serious problems with the aircraft's control surfaces. On the last run the landing gear was badly damaged and this delayed further trials for several weeks. A number of modifications and repairs followed and it was obvious that AS-6 V-1's engine was totally inadequate, but because of wartime priorities a more powerful unit could not be obtained.

In an attempt to generate slightly more lift during take-off the undercarriage legs were moved back by about 8in (20.3cm), which raised the nose of the aircraft further. Rolf Baltabol was concerned about the safety aspects of this modification and the possibility of AS-6 V-1 tipping forward during take-off, allowing the propeller to hit the ground. But when Sack suggested moving the undercarriage backwards by another 8in (20.3cm), Baltabol told him it was too dangerous and he refused to fly the plane in that condition. As a consequence the idea was dropped. Additional modifications followed which included the installation of brakes from a Junkers Ju 88 bomber, the use of even larger control surfaces and the installation of 150 lb (70kg) of ballast in the rear fuselage. When the next attempt to fly AS-6 V-1 was undertaken in April 1944 it became evident that the wings were too short to compensate for the engine's torque and so AS-6 V-1 had to be banked hard to the left. No more flights were attempted and Baltabol recommended wind tunnel tests and a new engine.

During the summer of 1944 I./JG 400 took over the Brandis airfield as a base for Me 163B rocket fighter operations. Their main function was to protect the massive chemical plant operated by I G Farben at Merseburg. This was the Reich's main production centre for synthetic fuel and it was of crucial importance to the German war effort. Apparently, some members of I./JG 400 discovered AS-6 V-1 in a hangar and Oberleutnant Franz Rössle (regarded by many of his fellow officers as something of a daredevil) tried to fly the aircraft (possibly with Sack's approval). But the undercarriage was badly damaged when it ran over some rough ground and AS-6 V1 was subsequently returned to storage.

On an unspecified date in early 1945 the Brandis Airfield was attacked by Allied warplanes and AS-6 V-1 was almost completely destroyed. What remained of the aircraft ended up on a scrap heap and all traces of AS-6 V-1 had disappeared when the units of the US Army's 9th Armoured Division arrived at Brandis on 20th April 1945.

Towards the end of the war Sack held discussions with engineers from Messerschmitt A G to explore the possibility of developing a more advanced aircraft, which Sack had named AS-7 V-1 or the Bussard (Buzzard). The idea was to combine the fuselage of a Messerschmitt Bf 109K-4 (the final production version of this aircraft) with a newly devised circular wing. Equipped with a DB 605 ASCM/DCM V-12 engine rated at 2,000hp (1,491kW) driving a four-blade propeller, AS-7 might have combined high performance with an exceptional STOL capability. It is also likely that the circular wing would have made it possible to carry more armaments than the Bf-109K-4. Some unconfirmed reports suggest that Messerschmitt had provisionally assigned the designation Me 600 to the AS-7, but nothing came of this fighter project.

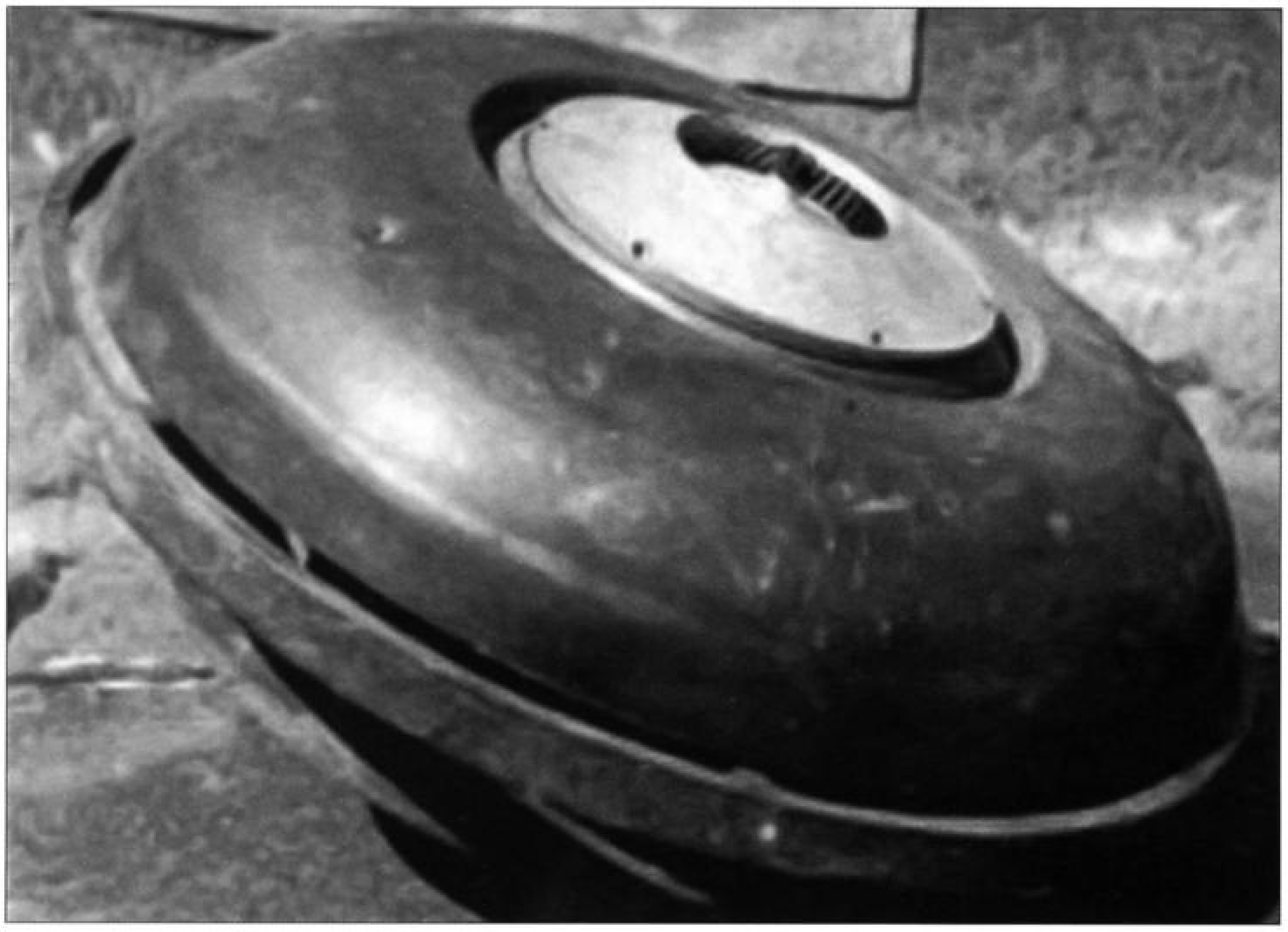
Ernst Heinkel, founder of Heinkel Aviation. via Bill Rose

This photograph of Rudolph Schriever is almost certainly genuine and may have been taken in prewar Prague. Bill Rose Collection

The Heinkel-BMW Flying Disc Story

According to the most reliable sources available, this story began in the spring of 1940 when a thirty-year-old Luftwaffe Hauptmann called Rudolph Schriever, who is thought to have gained an engineering degree from the University of Prague, was assigned by the RLM to work for the Heinkel Aircraft Company at Marienehe, Rostock. Schriever was put to work in the company's design section. He had been interested in VTOL (Vertical Take-Off and Landing) concepts for some time and was apparently influenced by work undertaken by the famous Romanian aerodynamicist Henri Marie Coanda. As described in Chapter One, Coanda had discovered an important airflow effect (The Coanda Effect). This was patented in 1934 and during the following year Coanda applied it to a flying disc concept called Aerodina Lenticulara.

Utilising some of Coanda's research, Schriever drew up plans for a VTOL disc-shaped aircraft and this study came to the attention of company chairman Ernst Heinkel

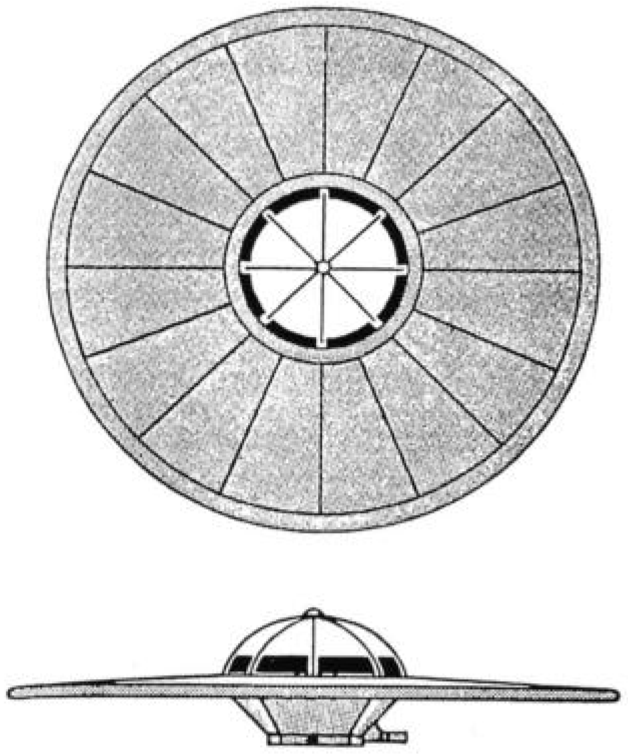


This object is claimed to be the original Schriever Flying Top proof-of-concept demonstrator, although it could just as easily be an unidentified piece of industrial equipment. Origin unknown, via Bill Rose

(1888-1958), who personally encouraged the Hauptmann to design a small, fully functional prototype. By early 1941, Schriever's blueprints were being used to construct a proof of concept model in one of the company's small workshops and it was called the V1 (Versuchs 1); informally the machine was also known as The Flying Top. With a diameter of about 2ft (61.0cm), The Flying Top is thought to have been propelled by a rotary fan, which was driven by an electric motor or possibly a compact two-stroke engine.

By the middle of 1942, The Flying Top had been tested and the results were sufficiently promising to encourage the construction of a full-size piloted version, capable of controlled VTOL. Not surprisingly, this machine was called the V2 and as is usually the case with most prototypes, smaller specialist aeronautical companies were employed to manufacture the more unusual components, while other parts were adapted from off-the-shelf pieces of hardware. The construction of V2 may have been undertaken in early 1943 at Heinkel's Marienehe facility, or possibly at a company site in Czechoslovakia. Unfortunately, no records have surfaced which show verifiable details of assembly or indicate when the first flight took place, but if we assume that V2 actually existed, it is likely that Schriever flew it on at least one occasion.

V2 has sometimes been referred to as the Flightwheel. Crude and undoubtedly rather fanciful drawings that date back to the late 1940s show a central cabin surrounded by a rotating wing. This alleged prototype may have had a diameter of about 25ft (7.6m) and there have been suggestions that a single stabilising fin was added to the central cabin section. The propulsion system can only be guessed at, but a strong possibility would be one or two Heinkel-Hirth turbojet engines.


Heinkel-BMW V3 drawing. via Bill Rose

A very interesting incident that appears connected to this project took place at the Praha-Kbely Airfield (northeast of Prague), during August or September 1943 and involved the secret test flight of an unusual disc-shaped vehicle. During World War Two Praha-Kbely was a major production and repair centre for various Luftwaffe aircraft and it would later become a Warsaw Pact Mikoyan MiG-21 jet fighter base during the Cold War. It is now the largest aviation engineering facility in the Czech Republic. The event was witnessed by approximately twenty-five members of the locally based C-14 Flight School and details eventually surfaced in the February 1987 issue of the respected German aeronautical magazine *Flugzeug*.

The author of this article (who was a member of C-14) claimed that the group were accidentally exposed to the test flight of a disc-shaped aircraft, (referred to as the 'Thing') which was moved out of a hangar, powered up and then made to undertake a brief hover, followed by a short flight just above ground level. The disc was described as having an aluminium colour and a diameter of about 20ft (6.1m). It was supported by four legs and had some kind of rotating component around the rim. Although the group was immediately instructed to leave the area, members of C-14 were aware of a second test-flight taking place and it is tempting to link this report directly to V2, which remains an interesting albeit unverifiable possibility. There are further reports of similar test flights at this complex, but no irrefutable documentation has been found.

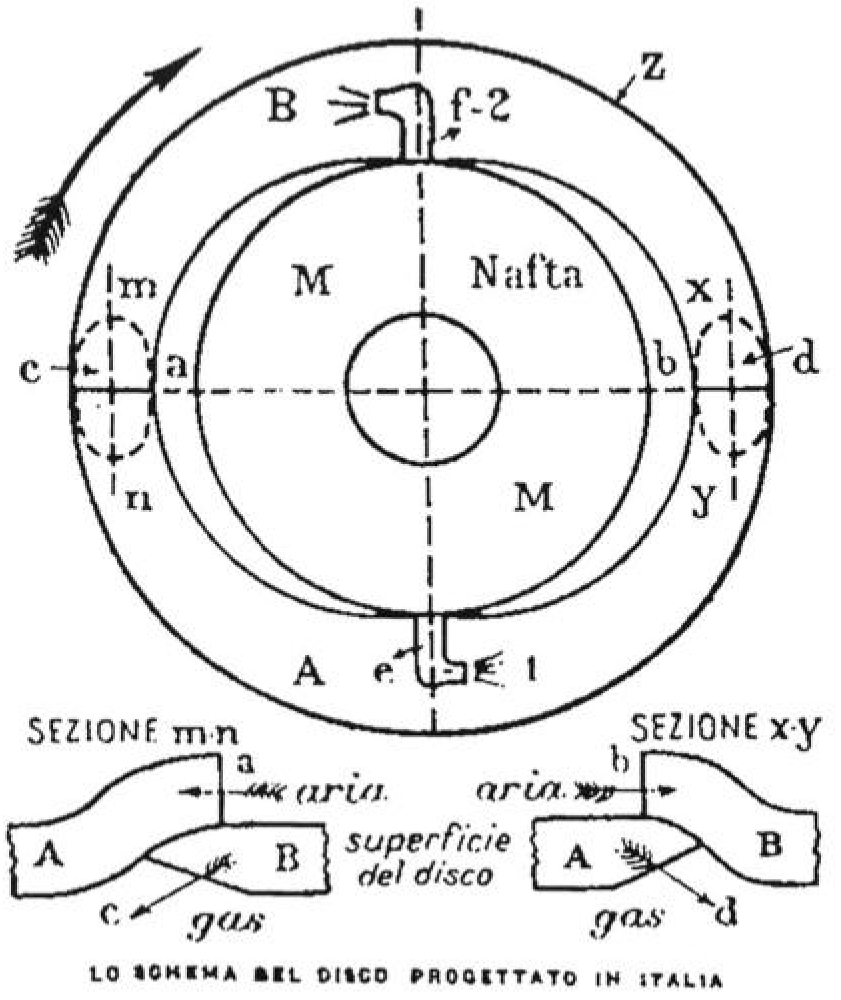
By the spring of 1944 Schriever's team had fully relocated from Rostock to a couple of small sites in Czechoslovakia, with most of the engineering and development work taking place at a facility within the Praha-Kbely complex. Without trying to jump to too many conclusions, it seems probable that Heinkel (possibly in association with Skoda) had been operating a test facility for prototype aircraft at Praha-Kbely for some time. Joining Schriever's team were several aeronautical designers and scientists that included the somewhat enigmatic Dr Richard Miethe, who apparently worked on both the V-1 and V-2 missile programmes.

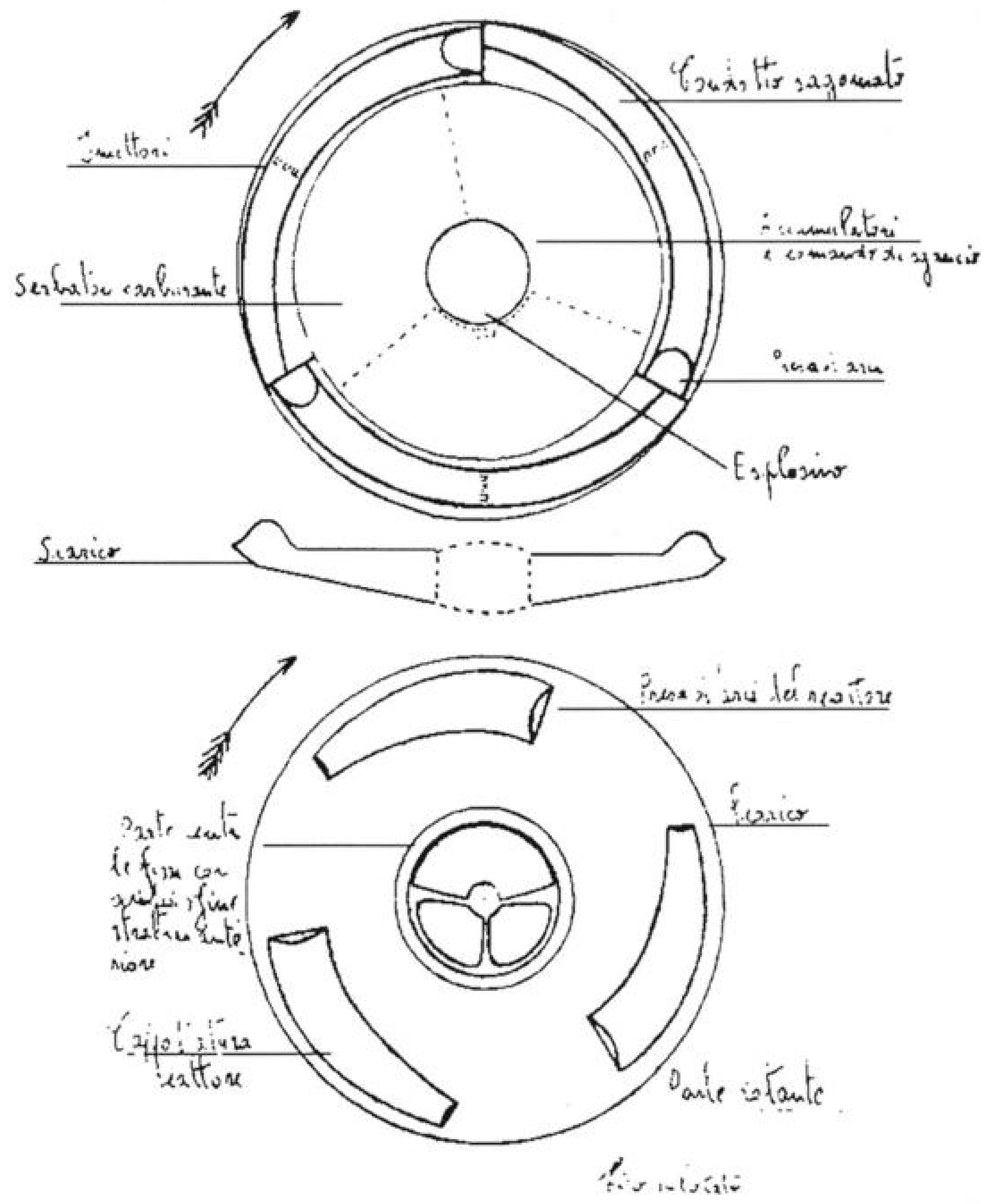
This is thought to have been at the Specialist Advanced Propulsion Section of BMW Bramo in Berlin-Spandau, which was directly associated with the Peenemünde rocket site. Dr Helmut von Zborowski, an Austrian scientist who held the rank of Lieutenant in the SS, ran this facility and undoubtedly had some degree of control over the flying disc project. Another possible recruit to the Prague team was Klaus Habermohl, an aeronautical engineer, also apparently employed by BMW-Bramo in some capacity under Dr von Zborowski. The next rather questionable member of this group is reported to have been Dr Giuseppe Belluzzo (1876-1952), an Italian turbine specialist who also became heavily involved with right-wing Italian politics.

Alleged photograph of Richard Miethe, possibly taken at a prewar rocket test site.
Bill Rose Collection

Under the continuing direction of Schriever, the Prague Group set about designing and building a larger and altogether more sophisticated flying disc with the designation V3. The Heinkel Company probably took responsibility for airframe assembly and testing, while BMW engineers worked on integrated propulsion systems, which may have accounted for most of the overall budget. Judging by the number of skilled engineers working for Avro Canada's Special Projects Group on a more advanced flying disc development project during the 1950s, it is likely that this unit comprised no more than about thirty to forty personnel.

Although Heinkel had pioneered the gas turbine, his organisation was widely perceived within the RLM to be an airframe manufacturer. This is probably the reason why Heinkel's Hirth Motoren engine company





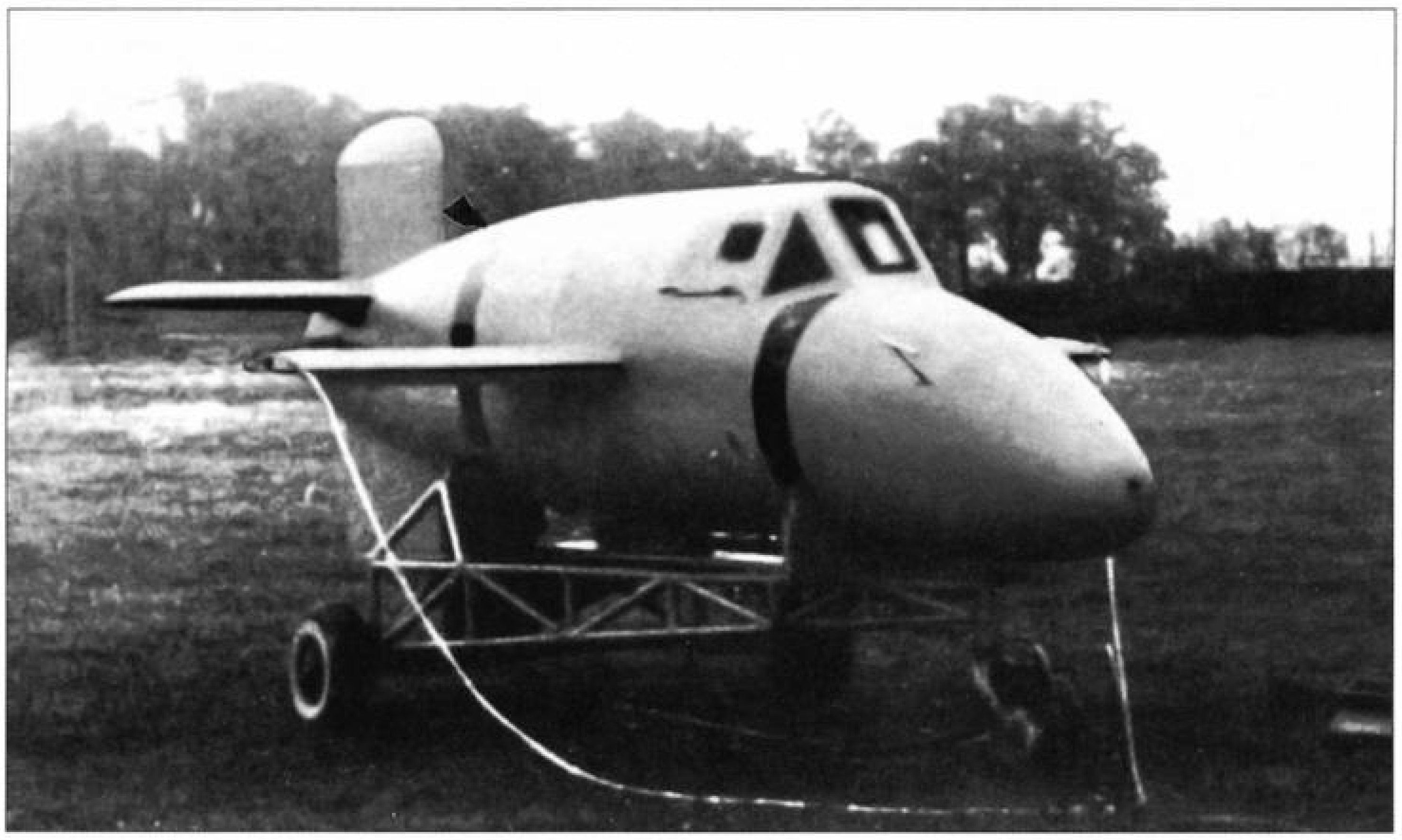
Above: **A drawing made by Giuseppe Belluzzo in 1942, which appeared in Italian newspapers during 1950. It appears to show the turbine propulsion system for a flying disc design. Belluzzo claimed to have been involved with work being undertaken by German engineers to develop a flying disc aircraft.** via Bill Rose

Right: **This drawing made by Dr Giuseppe Belluzzo shows the main features of a flying disc-shaped vehicle, which he produced in the early 1940s. Belluzzo has been linked to the Heinkel-BMW project at Prague, but there is no evidence to substantiate this.** via Bill Rose

based at the Stuttgart-Zuffenhausen facility was never allowed to achieve mass production with its jet engine designs, and the majority of Luftwaffe contracts went to BMW and Junkers. BMW's Bramo division at Berlin-Spandau were at the cutting edge of jet engine research, employing many of the world's finest engineers with more than five thousand full-time workers on site. Almost every new idea was explored and, conceivably, one of Zborowski's teams may have built an exotic high-powered Radial Flow Gas Turbine (RFGT) engine (a flat pancake design – working edge-on during level flight) that was ideally suited to Schriever's V3 circular-winged aircraft. This became an integral part of the design.

The V3 prototype was probably completed during the autumn of 1944 and sketchy details suggest that it was a major improvement over the previous aircraft. V3 is described as having a similar appearance to the Flightwheel, with an increased diameter of about 40 to 50ft (12.2 to 15.2m) and possibly using a new type of propulsive gas turbine. Designed for VTOL and expected to attain high subsonic speed in level flight, this aircraft would have been just what the Luftwaffe wanted. German airfields were under continual attack from Allied bombers and the idea of a high-speed combat aircraft which could operate from improvised sites was already promoting design efforts into rocket-powered point defence interceptors like the vertically launched Bachem Ba 349A Natter (Adder), which entered service during the last few days of the war.

Nothing is known about the testing and development of V3 and it is possible that this



Bachem Ba 349A Natter (Adder). This manned rocketplane entered service during the last few days of the war and it clearly illustrates the type of thinking taking place within the RLM as the war turned against Germany and the Luftwaffe began to urgently consider high-performance VTOL designs. via Bill Rose aircraft never flew, despite some wild claims to the contrary. By late 1944, a major administrative change appears to have taken place within the flying disc project and it is believed that the SS took complete control under the direction of General Dr Hans Kammler. Dr von Zborowski already answered directly to this ruthless Nazi general, who was responsible for all V2 missile and Me 262 jet fighter production.

With the SS running Schriever's project, this rapidly led to the construction of a new prototype called V7. (It is conceivable that V4, V5 and V6 were nothing more than paperwork studies.) Primarily designed by Miethe, V7 carried a crew of two or possibly three and the prototype may have possessed a diameter of about 60 to 70ft (18.3 to 21.3m); some sources claim a greater diameter but this is certainly incorrect. V7 was significantly more advanced than V3 and this design may have been built around an RFGT from the outset. Reichsmarschall Hermann Goering is said to have inspected the project on several occasions, but this remains unsubstantiated. However, Luigi Romersa (a 27-year-old Milan journalist who worked directly for Mussolini as an advisor) claimed during a 2004 television documentary to have been shown a prototype saucer in 1944 at Praha-Kbely, on the direct authority of Hitler.

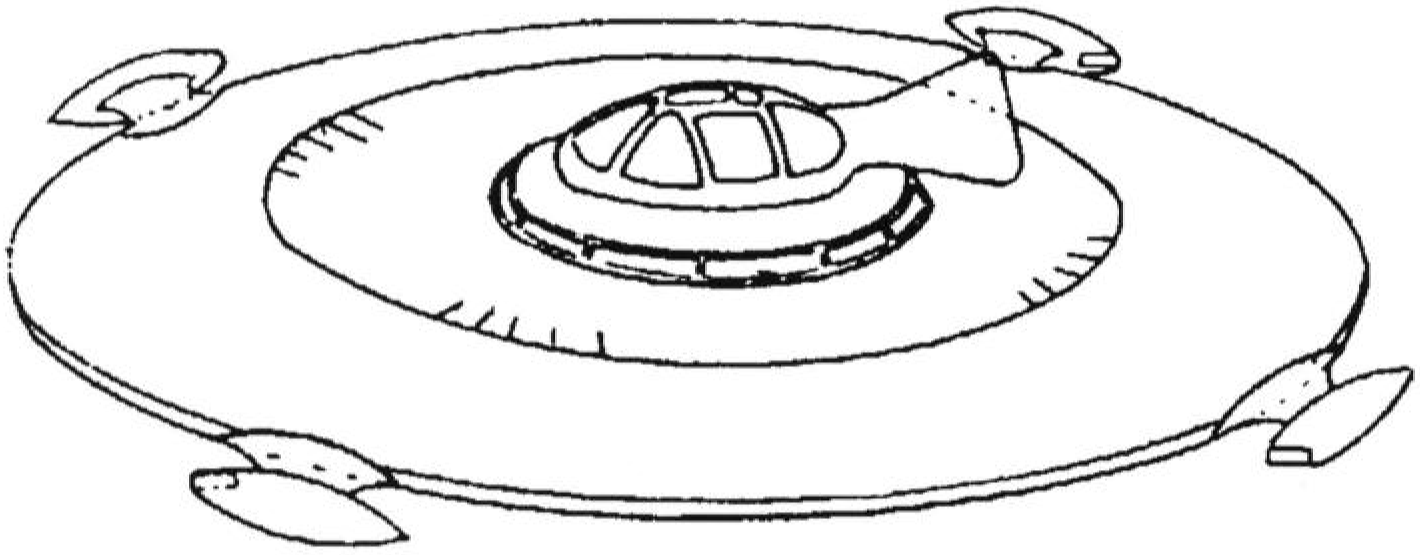
Intriguingly, several proposals for a flying disc surfaced in Rome during the late 1940s; these were reputedly (perhaps in part) based on V7. The work is attributed to an Italian engineer called Francesco de Beaumont who completed drawings of a saucer-shaped craft that utilised a large rotor that turned around the circumference of the vehicle supported by roller bearings. Four centrifugal-flow gas turbines, housed in pods, were attached to the outer edge of the ring at 90° spacing and they appeared to draw air from inlets in the fuselage. This arrangement was expected to generate enough lift for VTOL, hover and horizontal flight, with supersonic performance regarded as a distinct possibility at substantial altitudes.

SS General Hans Kammler, who took direct control of the Prague flying disc project towards the end of World War Two. via Bill Rose

Rotation of the main rotor would provide gyroscopic stability and de Beaumont considered several alternatives to drive the rotor, including pulsejets and ramjets. Within the centre of this unusual craft was an upper and lower cockpit and what appears to be a dorsal stabiliser seen on earlier drawings of Schriever flying discs. The aircraft would be supported on the ground by two retractable forward landing legs each having four wheels and a smaller wheel assembly at the rear. Most airframe components would be made from aluminium alloy and de Beaumont considered a variant without a cockpit, which would be flown by remote control.

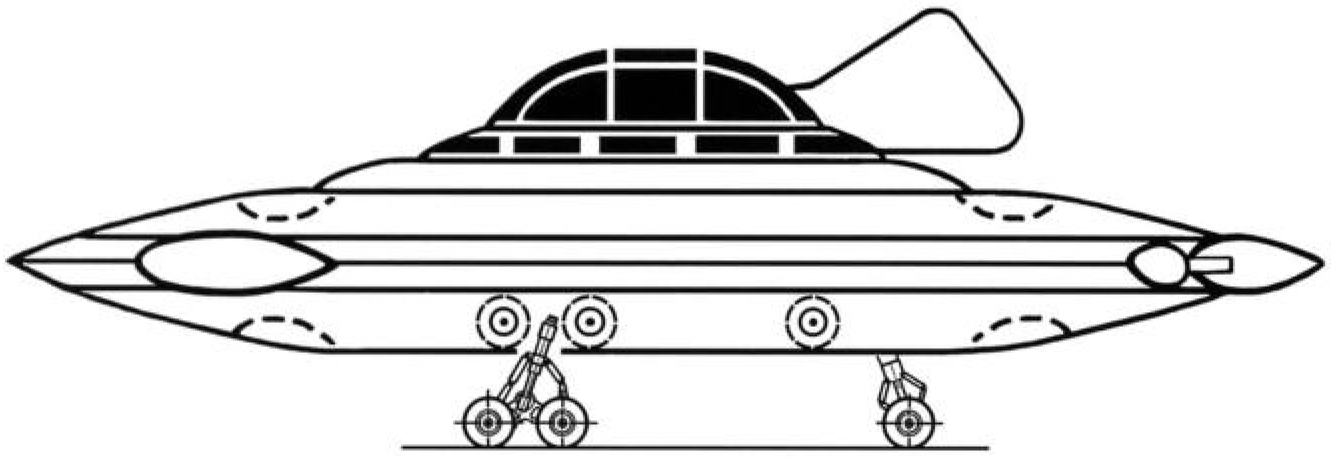
Many features of this design appear rather unsound and are not clearly explained in the limited documentation available. In April 1950, the inventor applied for a French patent, but nothing ever came of his concept. How much of this design was based on research carried out by German engineers at Praha-Kbely remains unknown, but there does appear to be a link to the Schriever project, with additional influences coming from concepts like the advanced Focke-Wulf Triebflügel VTOL fighter.

Returning to the V7, an engineer by the name of Georg Klein claimed to have observed the first flight of Miethe's saucer (at Prague) during February 1945. Others claim-



Above left: **A drawing attributed to the Italian engineer Francesco de Beaumont, which may be closely based on the Heinkel-BMW V-7.** via Bill Rose

Left: **Similar in appearance to other photographs showing the alleged V-7 prototype undertaking a test flight, this particular image is a fake. The best known pictures are three blurry images, which first appeared in French and Italian publications during 1952.** via Bill Rose



Above: **Side view of the flying saucer design attributed to the Italian engineer Francesco de Beaumont, showing the undercarriage. This design may be based on the alleged World War Two Heinkel-BMW V-7.** via Bill Rose

Right: **Luftwaffe pilot Andreas Epp, who claimed to have submitted designs later used to develop the flying discs built at Prague.** via Bill Rose

ing to have witnessed this event have said that V7 achieved supersonic speed during the first test flight and climbed to an altitude of almost 40,000ft (12,192m). This scenario sounds ridiculous and it is hard to imagine anything more than a brief tethered lift-off being attempted on an initial test flight. Intriguingly, Major Rudolph Lusar, the author of *German Secret Weapons of the Second World War*, stated that Schriever and Habermohl undertook the first flight of V7! Some reports have implied that the Waffen SS destroyed V7 when Field Marshal Wilhelm Keitel ratified the terms of surrender on 9th May 1945.

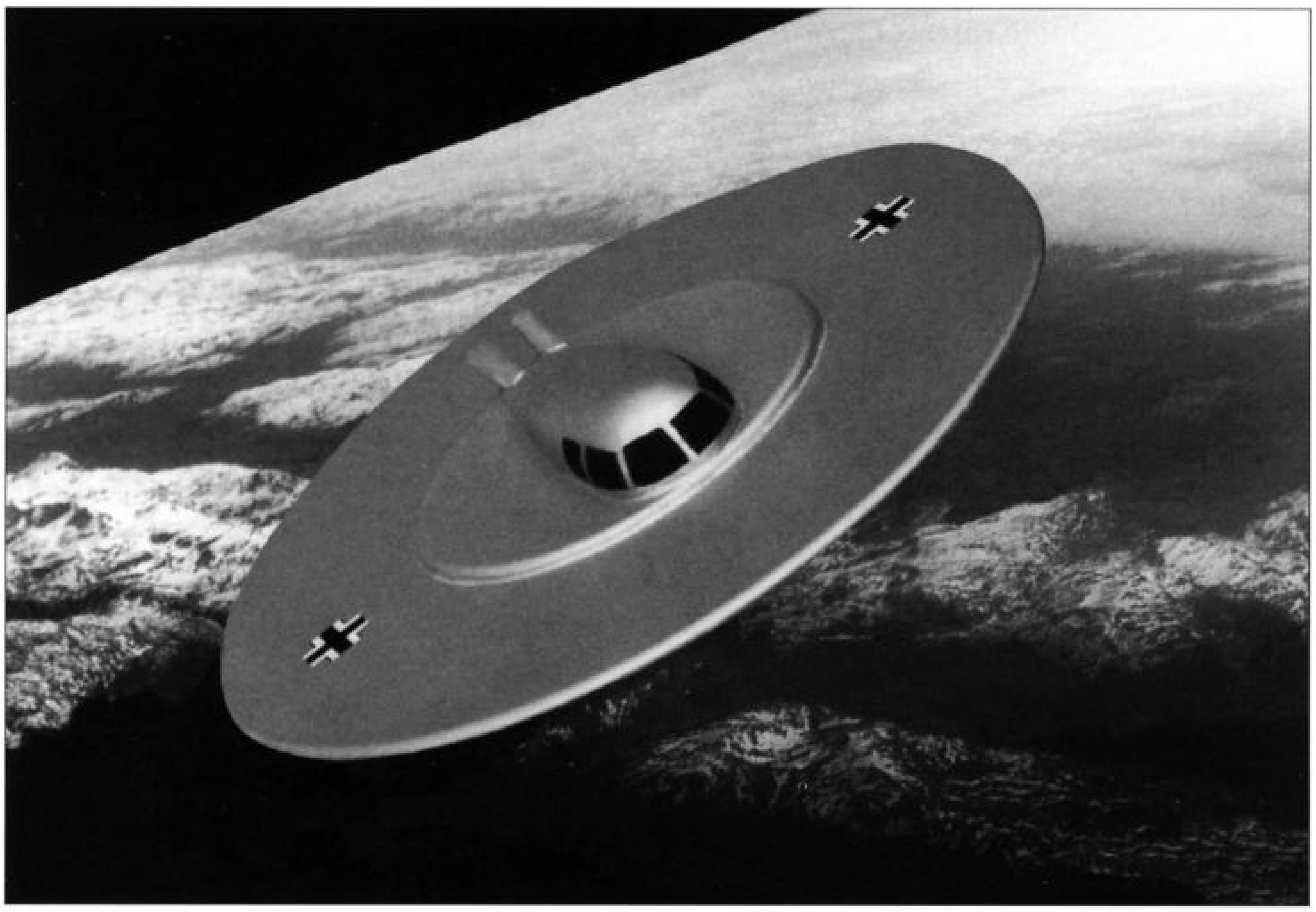
Alternatively, there are suggestions that V7 fell into Soviet hands, along with an even more advanced flying disc called V8 that was nearing completion. The design of V8 is attributed to Miethe, with reports that it used an advanced boundary layer reduction system and was capable of supersonic speed. However, it seems unlikely that V8 progressed beyond the conceptual stage and in reality this design is probably little more than the product of someone's fertile imagination.

When the war ended Rudolph Schriever made his way home to war-torn Bremerhaven, where he was lucky enough to secure a job driving for the US Army. Bearing in mind that most Germans were prepared to do whatever it took to put bread on the table, this was a stroke of good fortune for the former engineer. During the remainder of his life Schriever attempted to have his flying saucer story taken seriously and he finally died in rather mysterious circumstances during the mid-1950s.

His flying disc story first came to light in March 1950, when *Der Spiegel* magazine published an article about him. Several newspaper interviews followed and Schriever insisted that blueprints for his flying saucer had fallen into Soviet hands, enabling the Russians to build long-range reconnaissance craft (which were responsible for numerous UFO sightings). Curiously, the Americans, British and Russians showed no apparent interest in Schriever and some researchers insist this proves that he was a little unbalanced and his flying saucer story was pure fantasy.

Adding to the German flying disc mystery was former Luftwaffe officer Andreas Epp, who also originated from Bremerhaven. Until his death in 1997, Epp regularly claimed to have designed a small disc-shaped target drone while stationed in Norway during the War. Apparently, he forwarded plans to Armaments Minister Ernst Udet but heard nothing more. Epp said that some months later he discovered that development of his disc design was under way at Prague. Epp went on to claim that after the war he was recruited by Soviet intelligence to work in Russia on a prototype flying saucer and he was given responsibility for the design of this aircraft's control system. While this is an intriguing story it remains impossible to verify any of the details.

Various scraps of information about Miethe suggest that he escaped from Czechoslovakia in early May 1945 and headed west, finally making contact with American Intelligence. According to several reports, Miethe was



Artwork depiction of the Heinkel-BMW V-8 supersonic disc. It is probable that this design is little more than a product of someone's imagination! Bill Rose taken to the Allied Chief of Staff's Headquarters where SS Major Dr Wernher von Braun and about 115 of his rocket scientists were being debriefed by T-2 Technical Intelligence Personnel. From this point onwards things become sketchy, but some evidence suggests that Miethe was sent to Fort Bliss and finally Wright Field AAF, which became a principal location for evaluating captured German aeronautical technology. There is a widespread belief that Miethe was directly connected to the Avro Canada flying disc programme, but research in Toronto has failed to find any definite connection to Avro Canada's Special Projects Group.

Accounts of what happened to engine specialist Klaus Habermohl at the end of World War Two are even more vague. It has been claimed that he was taken prisoner by Russian troops and eventually transported to somewhere east of Moscow where a secret aviation project was taking place at an unknown Opytno Konstrucktorskoe Byuros (OKB or Special Design Bureau). This may or may not be true, but there is absolutely no evidence to show that Klaus Habermohl even existed.

Dr Belluzzo's alleged involvement with the flying disc project remains highly questionable. He is credited with completing his own design for a flying disc vehicle in the early 1940s, but there is no proof of a connection to the Heinkel-BMW project.

Conceivably, he may have sought to associate himself with post-war claims coming from Germany about flying saucers to attract some degree of fame. Belluzzo died in Rome on 21st May 1952. However, there is the question of Francesco de Beaumont's flying disc designs completed in Rome during the late 1940s. There may be a connection between Belluzzo and de Beaumont, but this remains a matter of hearsay and it is very easy to fill in missing pieces of the story with assumptions that later prove incorrect.

Dr Helmut von Zborowski went on to set up a design consultancy in 1947 called Bureau Technique Zborowski (BTZ). The consultancy worked for BMW and the French company SNECMA in the development of advanced VTOL fighter concepts based on wartime research. Various stories continue to circulate about the fate of SS General Dr Hans Friedrich Karl Franz Kammler, but it is probable that he was shot dead in early May 1945.

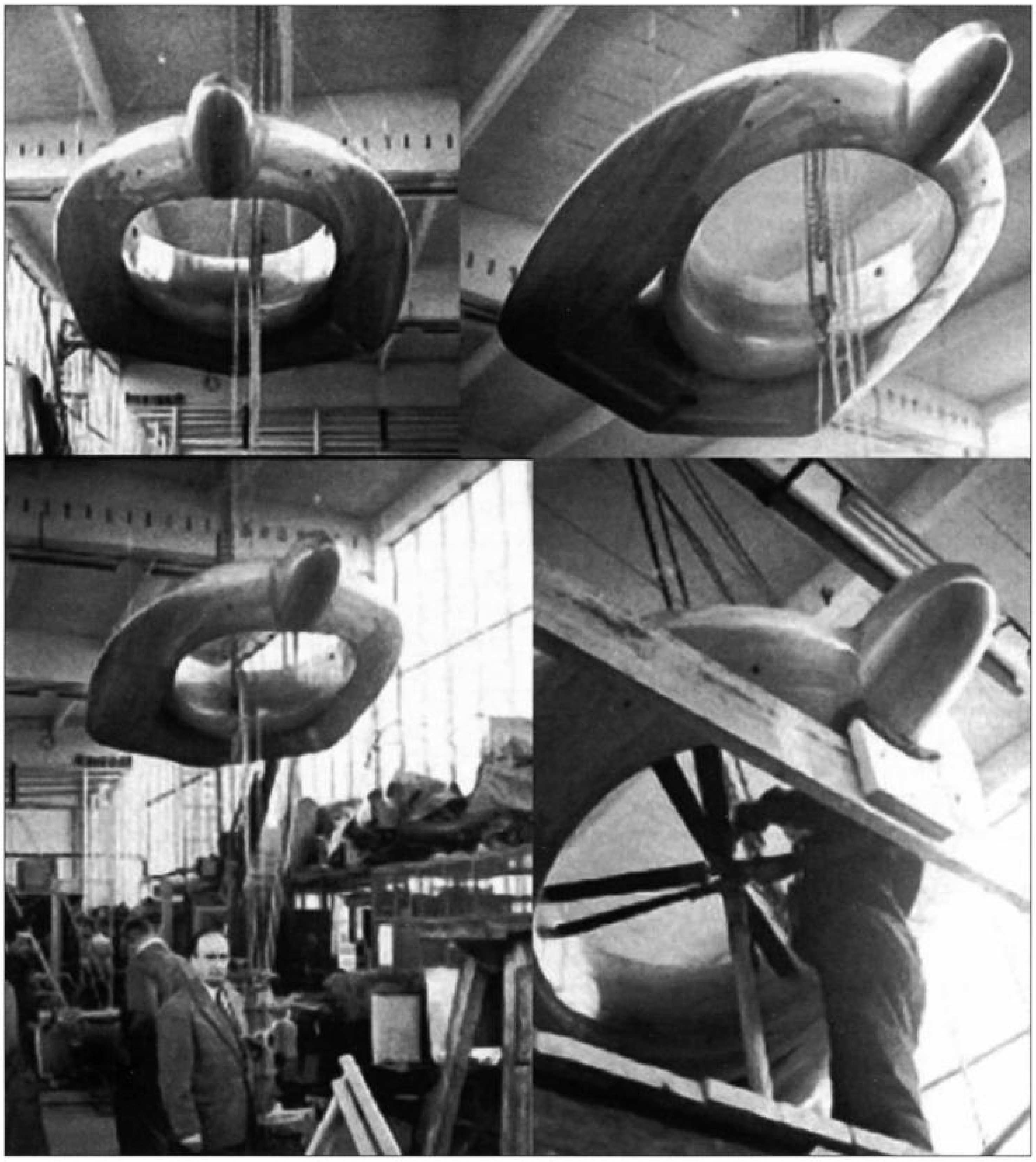
Critics will rightly pick up on the absence of records and hard evidence to support the Heinkel-BMW flying disc project, but it must be remembered that massive amounts of German wartime documentation were lost, intentionally destroyed, or retrieved by Allied Intelligence operatives and immediately classified. It is also worth mentioning that following a major fire at the Avro Aircraft Company in England during the late 1950s, virtually every company record was destroyed including details of Avro's most advanced military projects. So a lack of hard documentation does not automatically mean that an account of some particularly obscure aviation project is bogus.

Focke's VTOL Flying Saucer

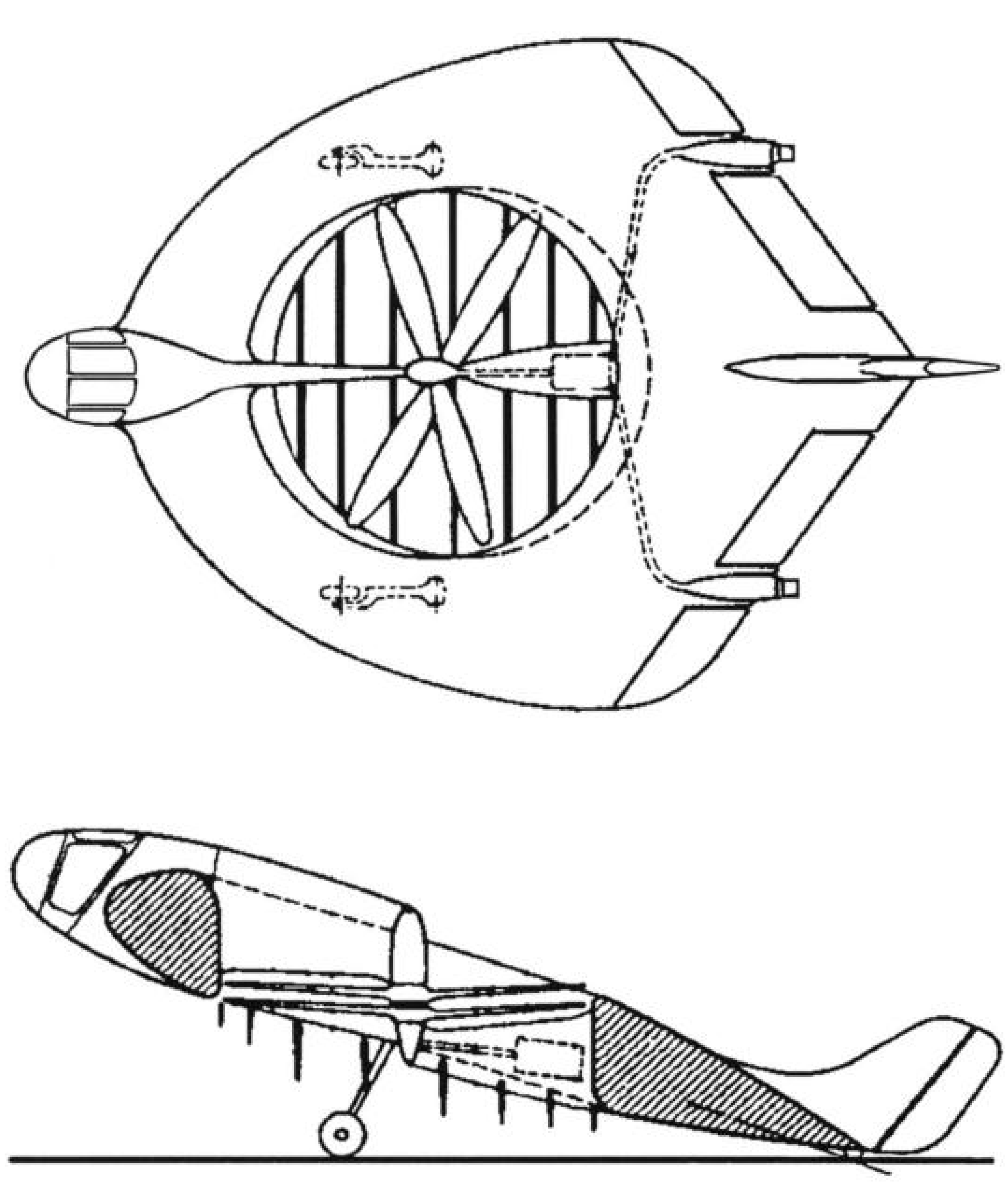
Focke-Wulf Flugzeugbau AG, the famous German aircraft company, was created in 1924. Contrary to some beliefs, there was no connection to the Netherlands firm run by Anthony Fokker. One of the three founders, Professor Heinrich Karl Focke (1890-1979), had something of a preoccupation with helicopters and in 1937 he decided to start an entirely separate company to develop and build them. Teaming up with Gerd Achgelis, they established the new business at Hoyenkamp near Delmenhorst and called it Focke-Achgelis Flugzeugbau.

Professor Focke directly managed Focke-Achgelis, developing helicopter aircraft that included the Fa 266 Hornisse (Hornet), Fa 223 Drache (Kite) and Fa 330 Bachstelze (Water Wagtail) autogyro. Many engineering innovations emerged from this company and Focke invented the turboshaft, which is a universal feature of modern helicopters. By the end of World War Two the company was actively working on the Fa 269 convertiplane, but this advanced design never progressed very far.

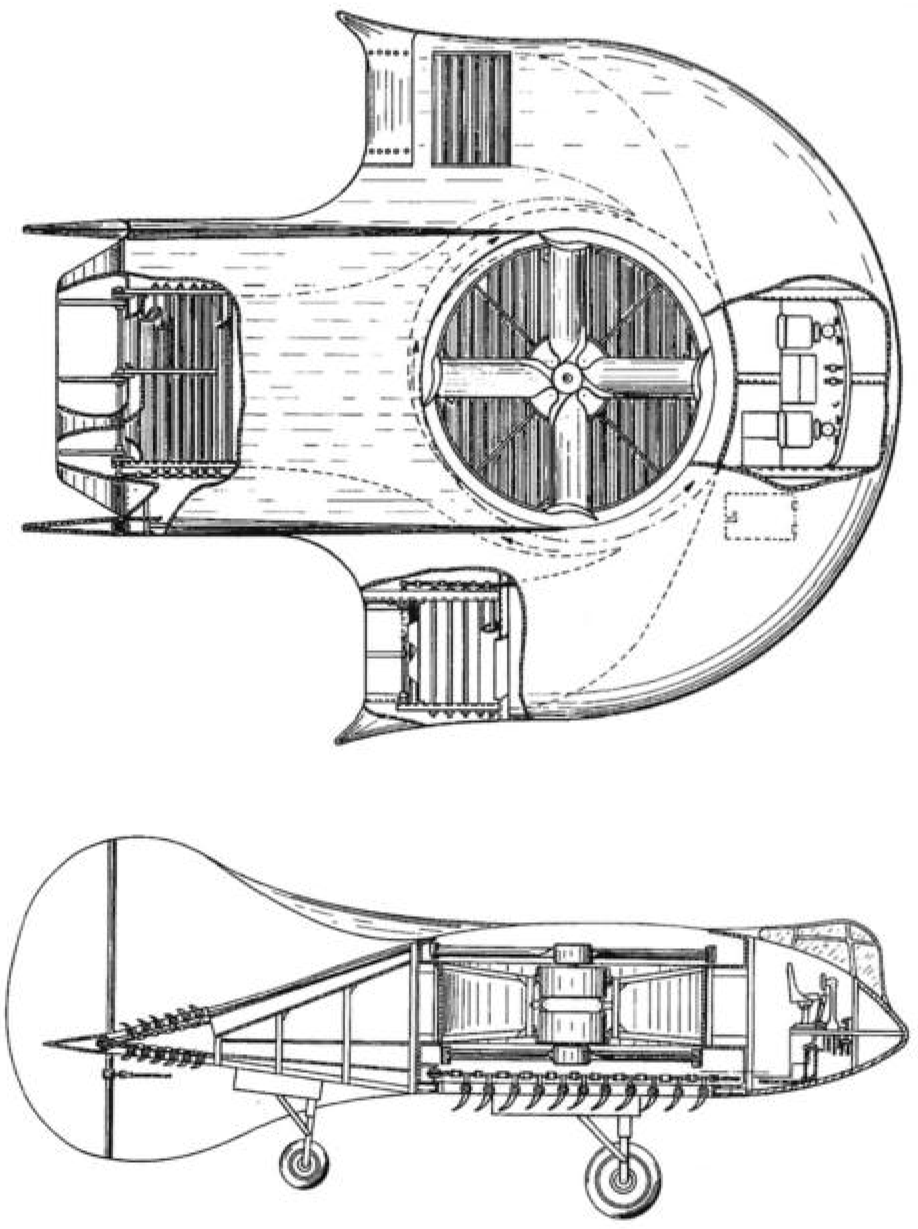
However, the most interesting concept under consideration was a little known saucer-shaped VTOL aircraft, which may have been jointly developed with one of Kurt Tank's Special Project teams at Focke-Wulf Aircraft. Professor Focke began producing designs for saucer-shaped aircraft during the late 1930s and his circular-winged VTOL concept continued to evolve during the course of the war. The aircraft finally became an oval-



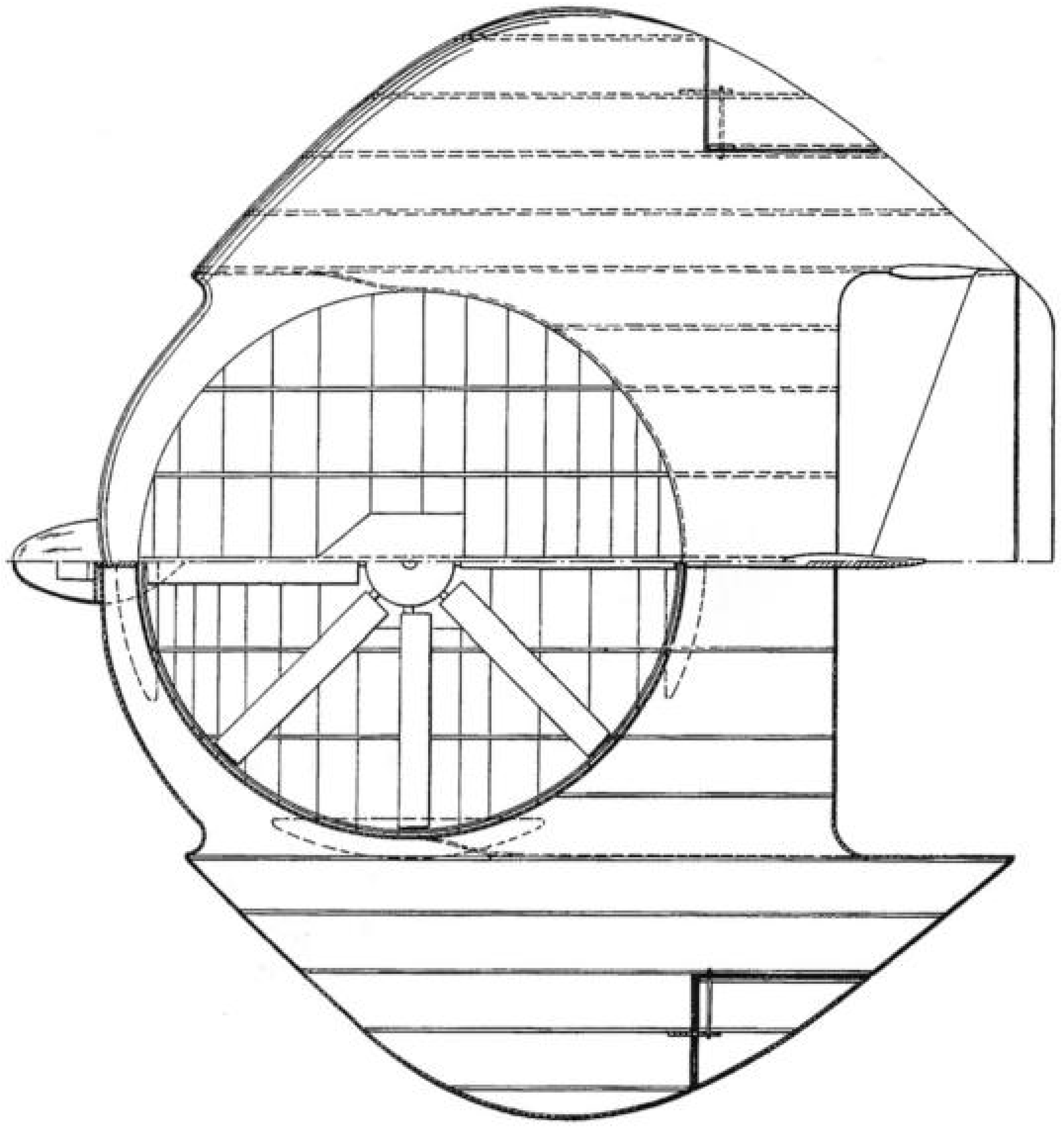
Several images of the Focke Achgelis VTOL wind tunnel test model. via Bill Rose

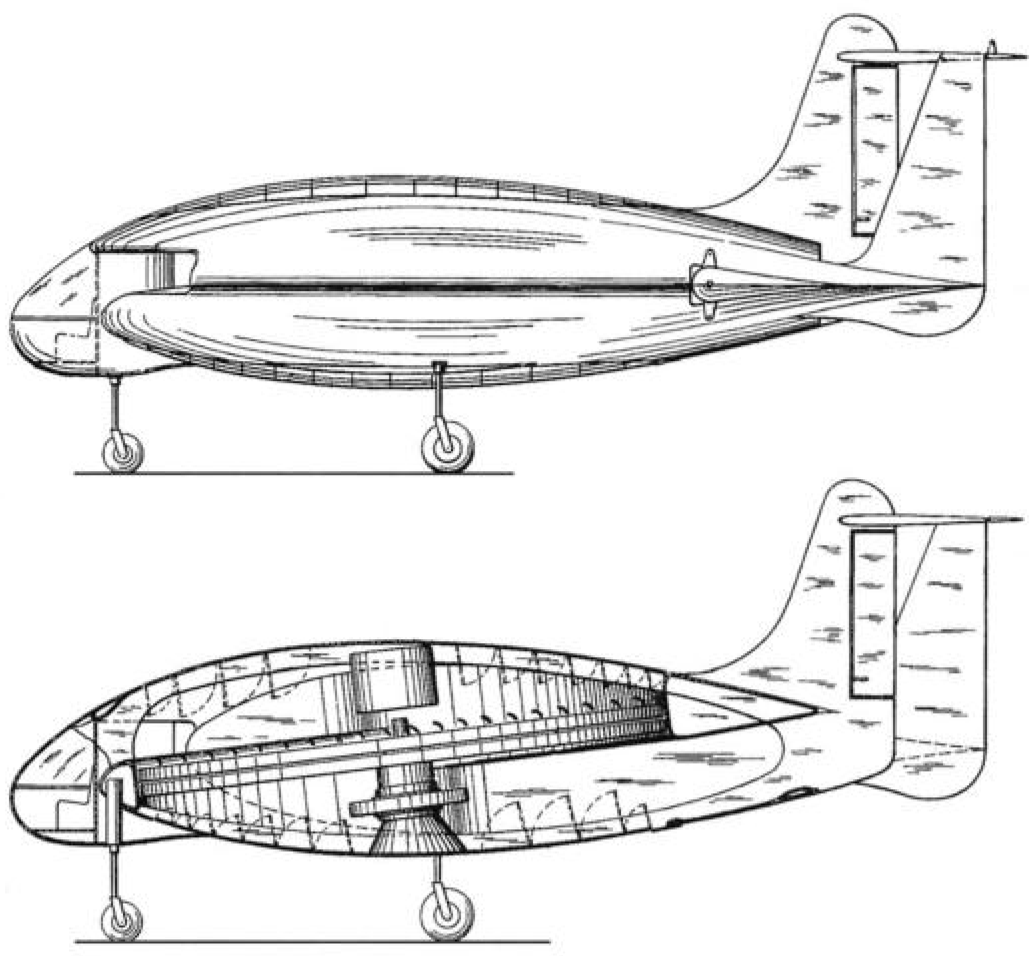


Drawing of the Focke Achgelis (later Focke-Wulf) VTOL design. This concept was briefly resurrected after World War Two and given the name Rochen (Ray). It inspired a number of US convertiplane concepts, although none reached the prototype testing stage. via Bill Rose



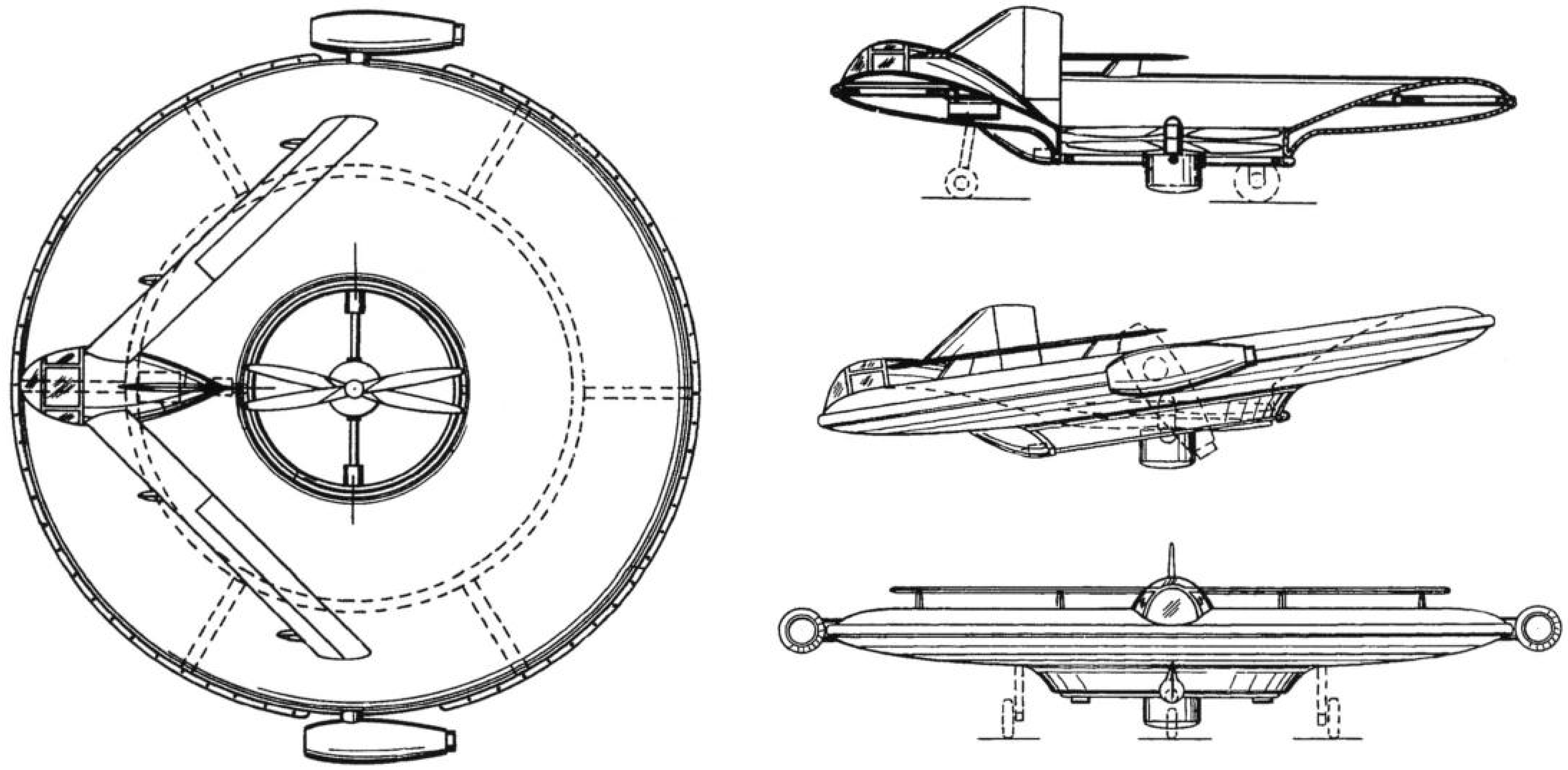
Charles Neumann and Hugo Baca produced this VTOL concept in 1945. It shared certain similarities with the Focke Achgelis VTOL concept. US Patent Office





Left: **Bearing some similarity to the wartime Focke Achgelis VTOL aircraft concept, the Goodyear Convertiplane was designed by Robert Ross in the early 1950s.** US Patent Office

Above: **Designed for possible shipboard use, Goodyear's Convertiplane used ducted fan propulsion for VTOL, hover and forward flight.** US Patent Office



The convertiplane designed by Homer Streib in the 1950s. This sophisticated VTOL design used jet engines in swivelling pods to assist with VTOL operation and boost performance in level flight. The US Patent Office

shaped aircraft during 1944 with primary propulsion being provided by two fully enclosed contra-rotating rotors (that eliminated torque problems), mounted in a centrally positioned duct.

The rotors would be driven by a single gas turbine located behind the duct and air would be forced downwards through a series of louvres in the aircraft's underside, allowing positive control in hover and low-speed flight. In level flight the louvres would be angled rearwards, supplemented by exhaust from the jet engine emerging through nozzles positioned on the trailing surface of each wing, which were adjustable for yaw and roll. To boost level flight performance further, there were proposals to use the jet engine exhaust ports as afterburners. In the event of an engine failure, it was felt that the aircraft would be capable of making an unpowered landing with the louvres closed.

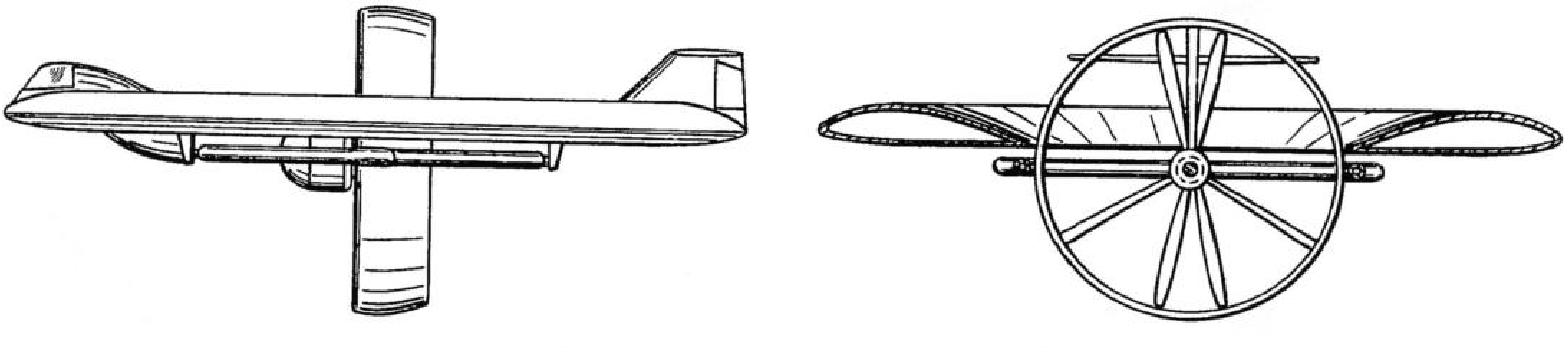
The pilot was located in a protruding cockpit nacelle, sitting in a conventional upright position, with two retractable forward wheels and a single retractable tailwheel supporting the aircraft. On the ground this VTOL disc would be raised by about 18° at the front, while the rotors would be level with the ground. Four control surfaces were positioned along the trailing edge of the wing and the design used a single tailfin and rudder. At some stage wind tunnel tests with small models were undertaken at Bremen, but nothing is presently known about this. Specifications and the anticipated performance remain unclear and there are no real indications of the aircraft's anticipated role, although it was probably conceived as a strike fighter.

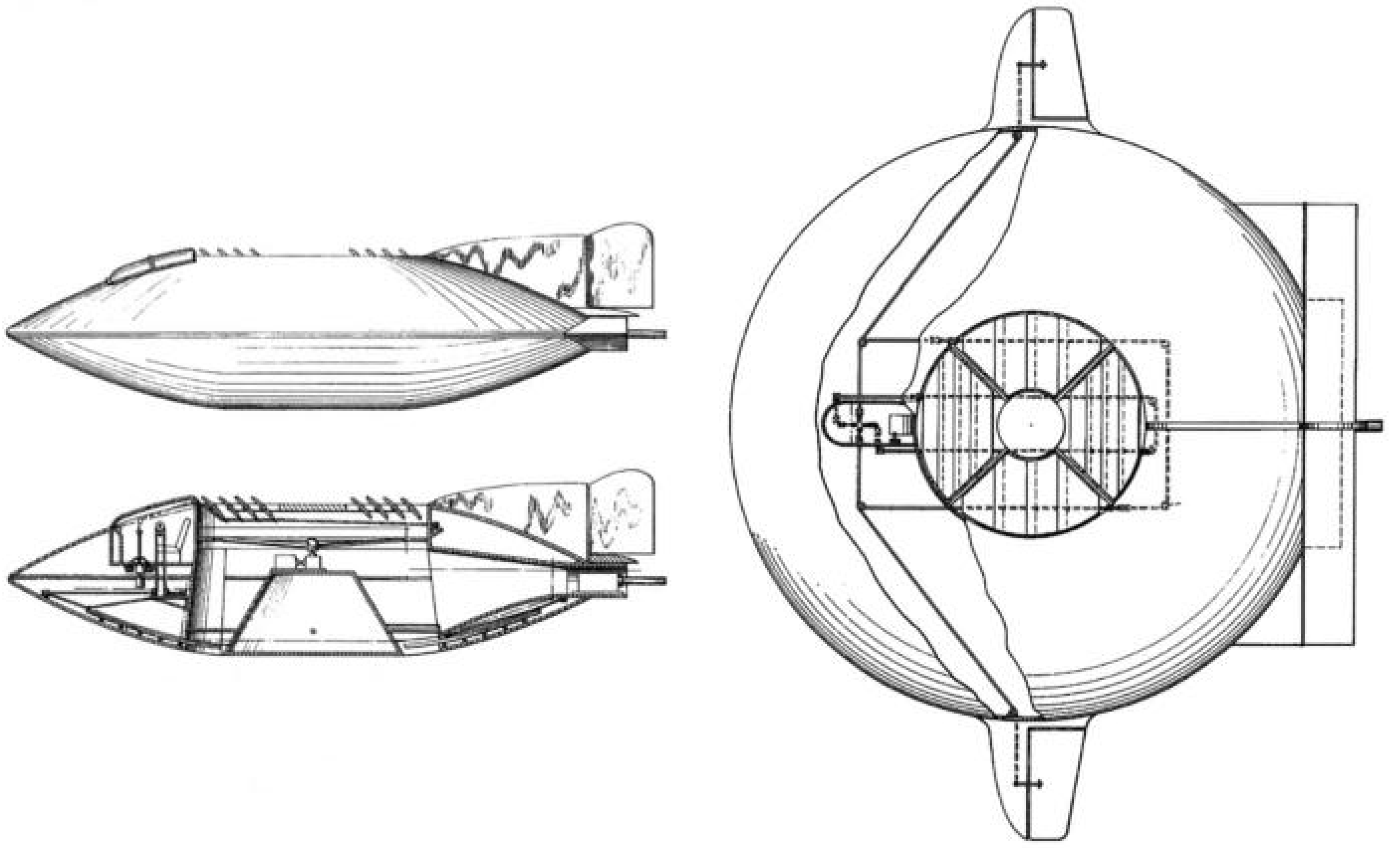
In 1955, the revived Focke-Wulf Aircraft Company at Bremen took a fresh look at the Professor's VTOL design and undertook some wind tunnel tests with a scale model mostly constructed from wood. The aircraft was now called Rochen (Aquatic Ray or Skate) but this programme didn't lead to the construction of a manned prototype and by 1958 interest in Focke's concept had started to fade.

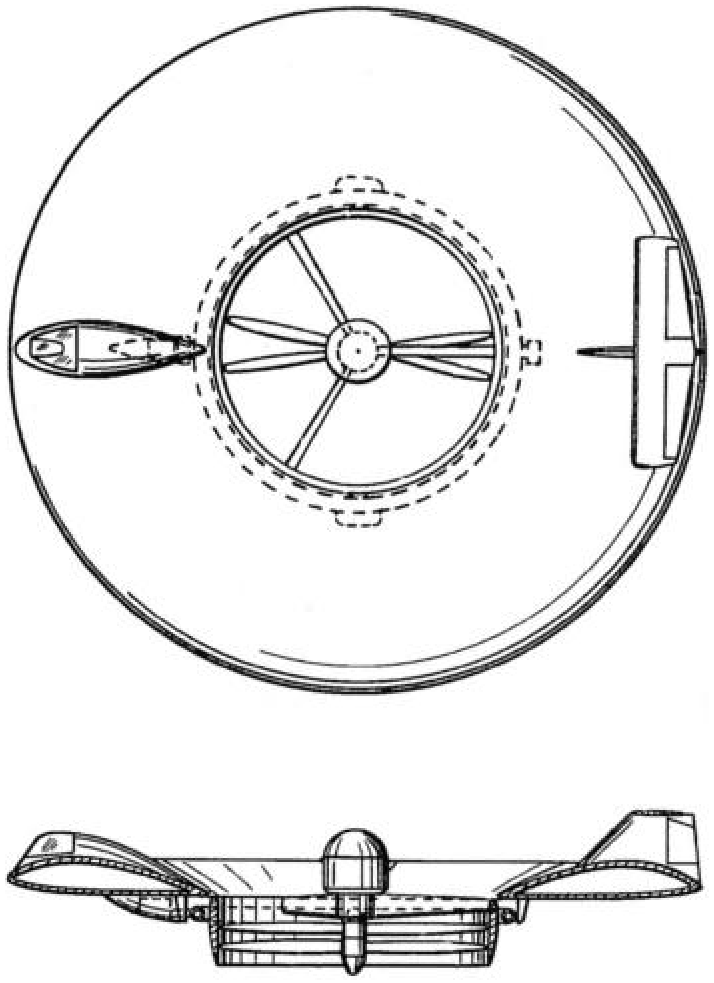
Earlier, in April 1945, American designers Charles Neumann and Hugo Baca produced an intriguing VTOL concept that shared a number of similarities with Professor Focke's design, although this appears to be nothing more than an unusual coincidence. Their two-seat arrowhead-shaped craft used an enclosed contra-rotating rotor assembly, with ducted airflow through louvres to allow VTOL operation and ducts to rearward-positioned louvres for level flight.

The Neumann-Baca design was followed in 1953 by a proposal submitted to the US Patent Office by the Goodyear Aircraft Company of Ohio, which was simply called a Convertible Aircraft. Although the company is not automatically associated with the construction of fixed-wing aircraft, during World War Two Goodyear became a sub-contractor for Vought and produced many copies of the F4U-1 Corsair naval fighter. The Convertible Aircraft design is visually similar to the wartime Focke Achgelis VTOL, but there are obvious differences that include the tailplane assembly and a tricycle undercarriage. The concept was credited to Robert Ross and, like the Focke Achgelis VTOL design, this aircraft utilised a set of large internal contra-rotating rotors for lift and level flight, with air ducted through louvres that would be almost closed during level flight. However, the Convertible Aircraft's powerplant was located directly below the rotor assembly, presumably with exhaust gas channelled into the airflow.

The Goodyear concept was closely followed by a series of studies undertaken by Homer Streib, a designer based in the San Diego area of California. Streib proposed several different circular-winged aircraft, all using a centrally mounted ducted fan to provide lift. The propulsion unit was to be gimballed for directional control and it contained two contra-rotating impellers designed to counteract torque. This arrangement would provide a full VTOL capability, with one early idea to tilt the entire assembly through 90° for horizontal flight. This seems to have been abandoned in favour of two additional turbo-







Top: **VTOL aircraft conceived by Homer Streib, which utilises a large rotating ducted fan unit for VTOL operations and forward flight.** US Patent Office

Above: **VTOL flying saucer concept using a ducted fan design, which was created by Harold Naught during 1948.** US Patent Office

Right: **A simplified design for a convertiplane produced by Homer Streib in the 1950s. This aircraft would use two-bladed contra-rotating blades for lift and forward propulsion.** US Patent Office

jets, either housed in the fuselage or attached in pods.

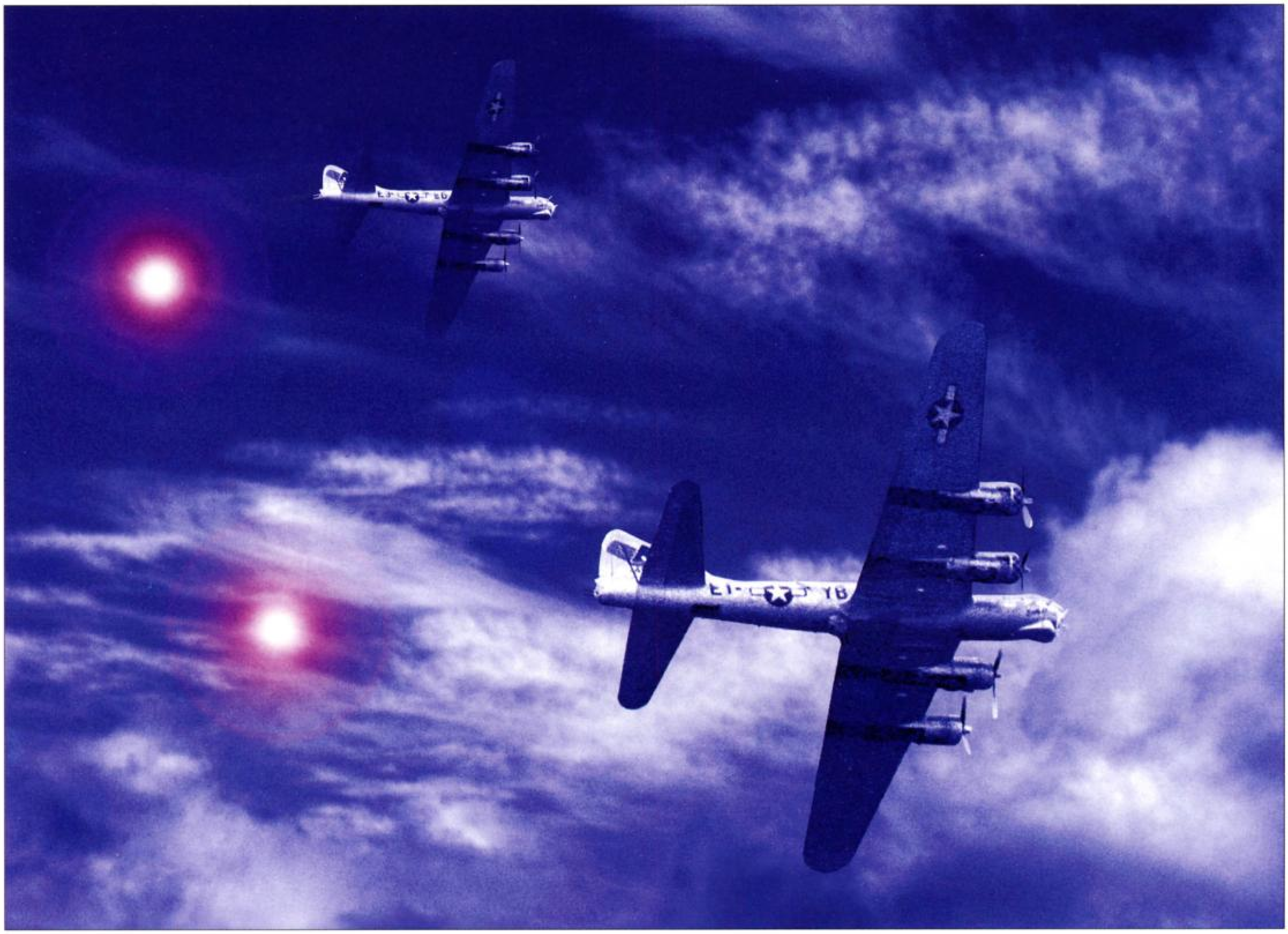
A possibility also explored by Streib was boundary layer reduction and, although all his proposals vary in detail, each one is developed from the same concept. Streib indicates that wind tunnel testing was undertaken and an upper V-shaped wing with additional control surfaces was added behind the cockpit to counteract tilting problems. These designs were fitted with a tricycle undercarriage and the role envisaged for Streib's aircraft is unknown, but it seems likely that a naval application was envisaged.

One other concept that used a similar approach to propulsion was produced by Harold Naught, who applied for a US Patent in June 1948. Naught was interested in producing a small saucer-shaped one-man utility aircraft based around a ducted fan system. His design used shutters to regulate the air inlet and the aircraft was equipped with small wingtip ailerons for additional flight control. Although Naught's design never progressed beyond a paper study, the work proved quite influential with other aerodynamicists.

Foo Fighters

One the enduring mysteries of World War Two must be those eerie lights that sometimes shadowed Allied aircraft on bombing missions across Europe and parts of the Pacific. Given the name Foo Fighters by aircrews, the first documented use of this term appears to have been by Lt Donald Meiers, who was a pilot with the USAAF 415th Night Fighter Squadron. This term originated from a syndicated US comic cartoon strip called Smokey Stover, which was created by Bill Holman (1903-1987). The series ran in many newspapers from 1935 until Holman's retirement in 1973. In the series, Smokey Stover drove a fire truck known as the Foomobile and this quirky character called himself a Foofighter (Holman said that he first saw the word Foo on the base of a Chinese figurine).

A number of USAAF aircraft operating in Europe during 1944 and 1945 were decorated with Smokey Stover artwork. Allied radar operators began using the expression Foo Fighter to describe an unidentified contact from late 1944 onwards, after the name had appeared in magazines and newspapers as a slang reference to UFOs. From about 1942 onwards USAAF and RAF aircrews had been reporting strange (mostly ball-shaped) lights following or pacing their aircraft, but most incidents occurred from 1944 onwards in the European theatre, which created the belief that a new type of German weapon was being tested.



Simulation of Foo Fighters trailing B-17 bombers across the war-torn skies of Europe. Bill Rose

Foo Fighter reports prompted US General William J Donovan of the OSS (Office of Strategic Studies – a special ops CIA predecessor) to examine the matter with a small team of technical staff. Whether these investigations went much further than the collection and analysis of reports remains unclear, but Donovan is understood to have concluded that the phenomenon was unusual, but not new Nazi technology. The RAF set up a similar small secret committee to study Foo Fighters and they were equally concerned that these unidentified lights might be some new and unusual type of secret German weapon. In keeping with their US counterparts, the RAF finally decided that Foo Fighters were harmless and probably caused by some unusual form of electrical phenomena perhaps related to St Elmo's Fire.

The fact that Foo Fighters existed is not in dispute, because the reports of mysterious aerial lights are too numerous to dismiss, but in reality the Americans and British authorities probably had no real idea what they were dealing with. Today, many diehard UFO investigators continue to insist that Foo Fighters were small alien reconnaissance vehicles spying on mankind's aggressive activities. An alternative theory has been promoted by some conspiracy theorists, who say that Foo Fighters were small, unmanned aerial vehicles built in great secrecy by Nazi scientists. This idea has gained a degree of respectability, despite the fact that no hard evidence exists to support the claim.

To explain this, there have been suggestions that the technology was captured by the Allies and suppressed because of its importance. Yet, wartime censors were happy to allow media discussion of Foo Fighter incidents and one of the earliest reports appeared in *The New York Times* on 14th December 1944. It talks of floating silver balls seen during daylight hours, which were said to be a new German weapon. The 15th January 1945 issue of *Time Magazine* described Foo Fighters as 'the most puzzling secret weapon that Allied fighters have yet encountered'. This article goes on to suggest that Foo Fighters might be designed, '1) to dazzle pilots; 2) to serve as aiming points for anti-aircraft gunners; 3) to interfere with a plane's radar; 4) to cut a plane's ignition, thus stopping its engine in midair'.

The same week's issue of *Newsweek* had this to say about Foo Fighters: 'Possibly they are the results of a new anti-radar device which the Germans have developed. On the other hand, they may be the exhaust trails of a smaller model of the radio-controlled Messerschmitt 163, a rocket-propelled flying wing. Day bombers have met the Me 163, which has an explosive charge in the nose and is apparently designed to crash into Allied planes. When one pilot closely inspected foo-fighters tagging him however, he detected nothing but the spheres.'

Germany had already demonstrated its substantial technical lead in aviation and rocket technology, so a small remote-controlled craft might have seemed possible, although there are no verifiable reports that these objects physically interfered with Allied aircraft. The leading proponent of the secret weapon theory was Renato Vesco (1924-1999), an Italian aircraft engineer based in Genoa. He claimed that Foo Fighters were small, unmanned robot vehicles called Feuerball (Fireball), which were designed to emit radio frequency pulses that interfered with the electrical systems of enemy aircraft.

Vesco, who said he had worked on secret projects for the Germans during the War, maintained that the Feuerball was developed at a Luftwaffe research facility near Oberammergau in Bavaria and equipped with a device capable of transmitting high frequency pulses. Apparently engineers from Henschel and Zeppelin, working directly under the SS, were responsible for designing Feuerball. These small, unmanned vehicles are described as disc-shaped and powered by a very compact type of RFGT, which generated the brilliant orange or red exhaust glow that readily explained the descriptions of Foo Fighter objects.

Vesco claimed that after Germany's surrender the technical data concerning the Feuerball was secured by British Intelligence and immediately classified Top Secret. This is an interesting and neat explanation for numerous late-World War Two sightings of Foo Fighters, but there appears to be no real substance to it. Aside from never managing to track down Vesco while he was alive, it is worth noting that he would have been no more than twenty-one years of age when the War in Europe concluded, which would undoubtedly limit his apparent involvement with any top-secret Nazi air defence project. Nor does the Feuerball hypothesis easily explain why there were sightings of brilliant globes above the Pacific during the war with Japan. Some people have suggested these incidents came about after a technology transfer from Germany to Japan.

Whatever the truth, there can be little doubt that there was official concern about these frequent encounters with balls of light over occupied territory. Towards the end of 2002 American aviation researcher Joel Carpenter discovered a previously secret USAAF Intelligence Log (UKX-23426) dated 27th January 1945. This intriguing document warns of new German aviation technology that might produce magnetic pulses capable of interfering with the ignition systems of aircraft engines. Countermeasures are suggested, which take the form of component shielding. The overriding problem with the secret weapon theory is one of technological limitation and a device like the Feuerball that incorporated such a concentration of advanced engineering would have been way beyond the capabilities of German wartime science, or for that matter any other country, during the 1940s.

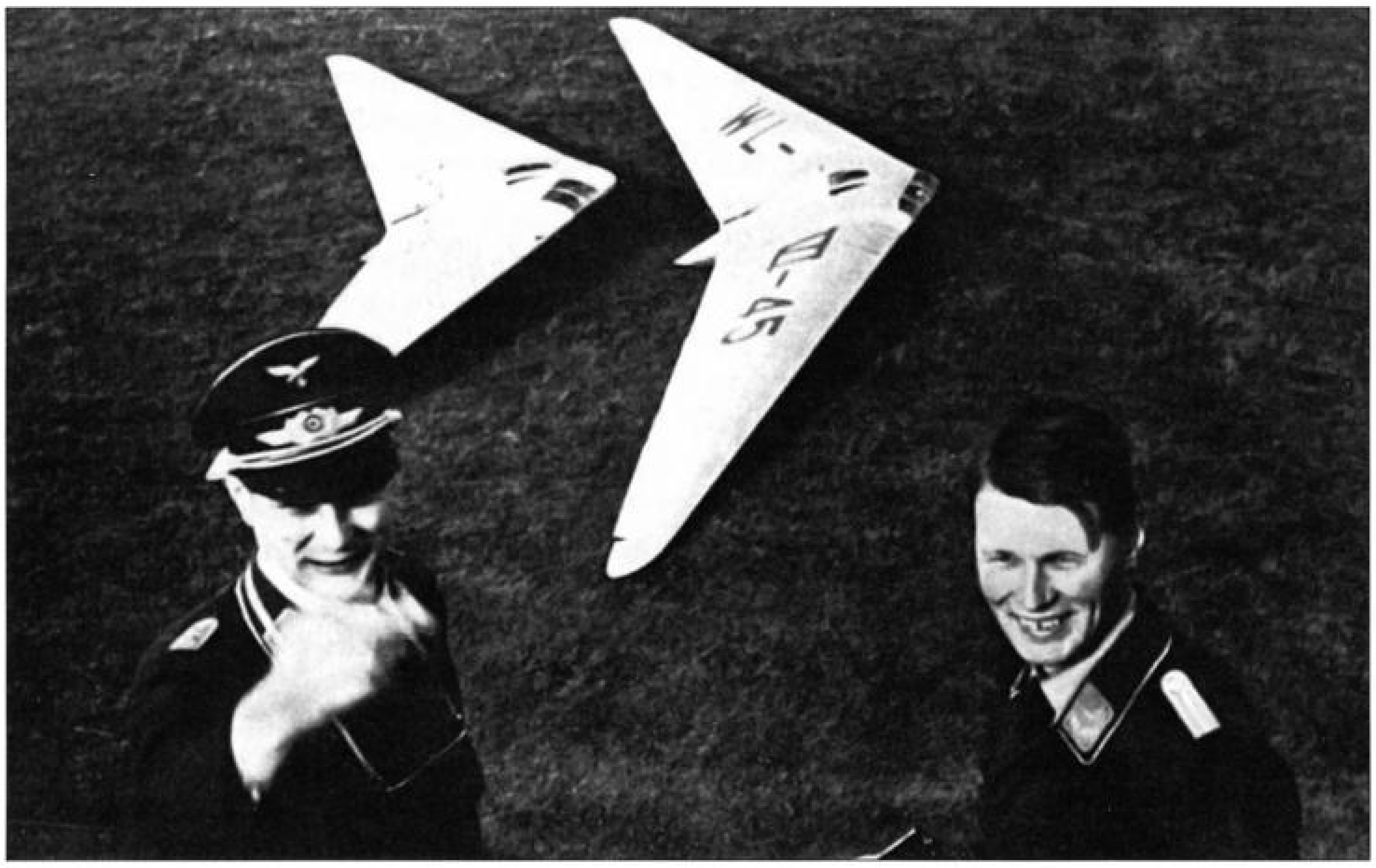
Such a craft would require a very sophisticated guidance system and a reliable radio link to a command centre. Computers were barely a reality at this time and artificial intelligence was pure science fantasy, so a Feuerball with a mind of its own was completely out of the question. Add a method of generating powerful electromagnetic pulses and a very exotic engine to this package and you have something that appears to come straight from someone's over-active imagination. That said, the glowing balls of light seen by Allied aircrews were real and can probably be linked to some unidentified natural phenomenon like ball lightning. It would be nice to be wrong about Foo Fighters, but the secret weapon hypothesis remains highly unlikely.

The Horten Brothers and Flying Discs

Reimar Horten (1915-1993) and his well-connected brother Walter (1913-1998) began to design and build sophisticated tailless gliders during the early 1930s. At the start of World War Two, both brothers joined the Luftwaffe as pilots. In 1942, Major Walter Horten took command of Sonderkommando (Special Detachment) 9 based at Göttingen Airfield, where he was soon joined by his brother. With their considerable experience in aeronautical design, Sonderkommando 9 would (almost exclusively) develop their flying wings into military aircraft.

The brothers now turned their attention to the idea of a jet fighter based on the flying wing concept. This led to the astonishingly advanced Horten IX/Gotha Go 229 fighter-bomber that was initially constructed in the Göttingen workshops and had entered production when hostilities ceased. The one-man Go 229 with its 55ft (16.7m) wingspan was potentially capable of reaching more than 600mph (965km/h), which was roughly 130mph (209km/h) faster than the most advanced Allied piston-engined warplane (the outstanding North American P-51H Mustang). Furthermore, the Go 229 was expected to have a maximum altitude of 52,000ft (15,849m), which was 12,000ft (3,657m) above the P-51's ceiling. In short, the overall performance of this aircraft was many years ahead of its time.

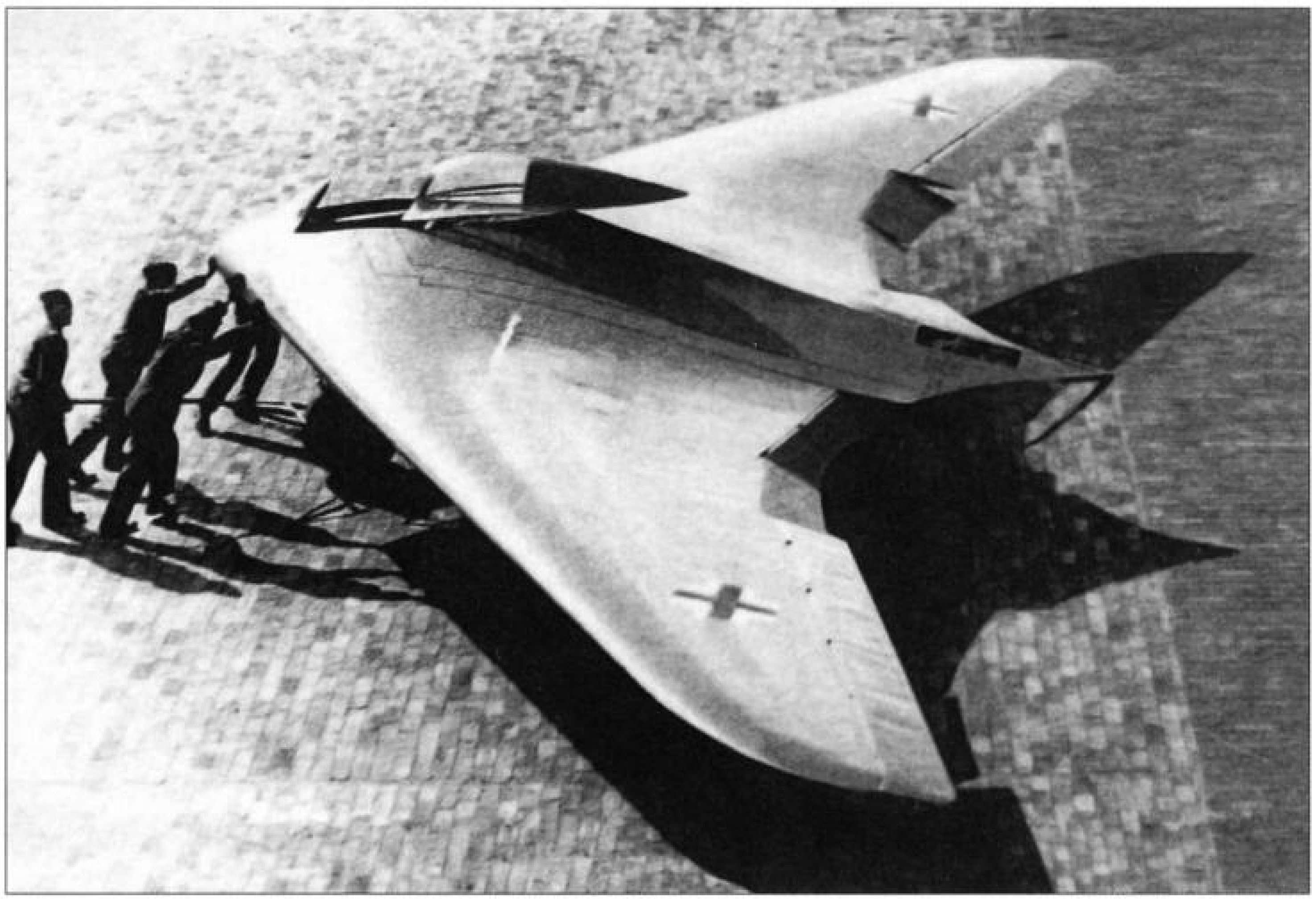
In appearance, the Go 229 was a smoothly contoured one-piece boomerang with no significant protrusions, powered by two Junkers Jumo 004 turbojets recessed in the fuselage. The sleek shape, in combination with low-cost constructional materials, might have generated a relatively small radar signature and during the 1990s a number of well-known researchers drew attention to this possibility. They suggested that the Go 229 was intended to be stealthy and emphasis was placed on the use of a 17mm-thick plywood sandwich for the skin, which containing a middle layer of resin-bonded sawdust and charcoal.

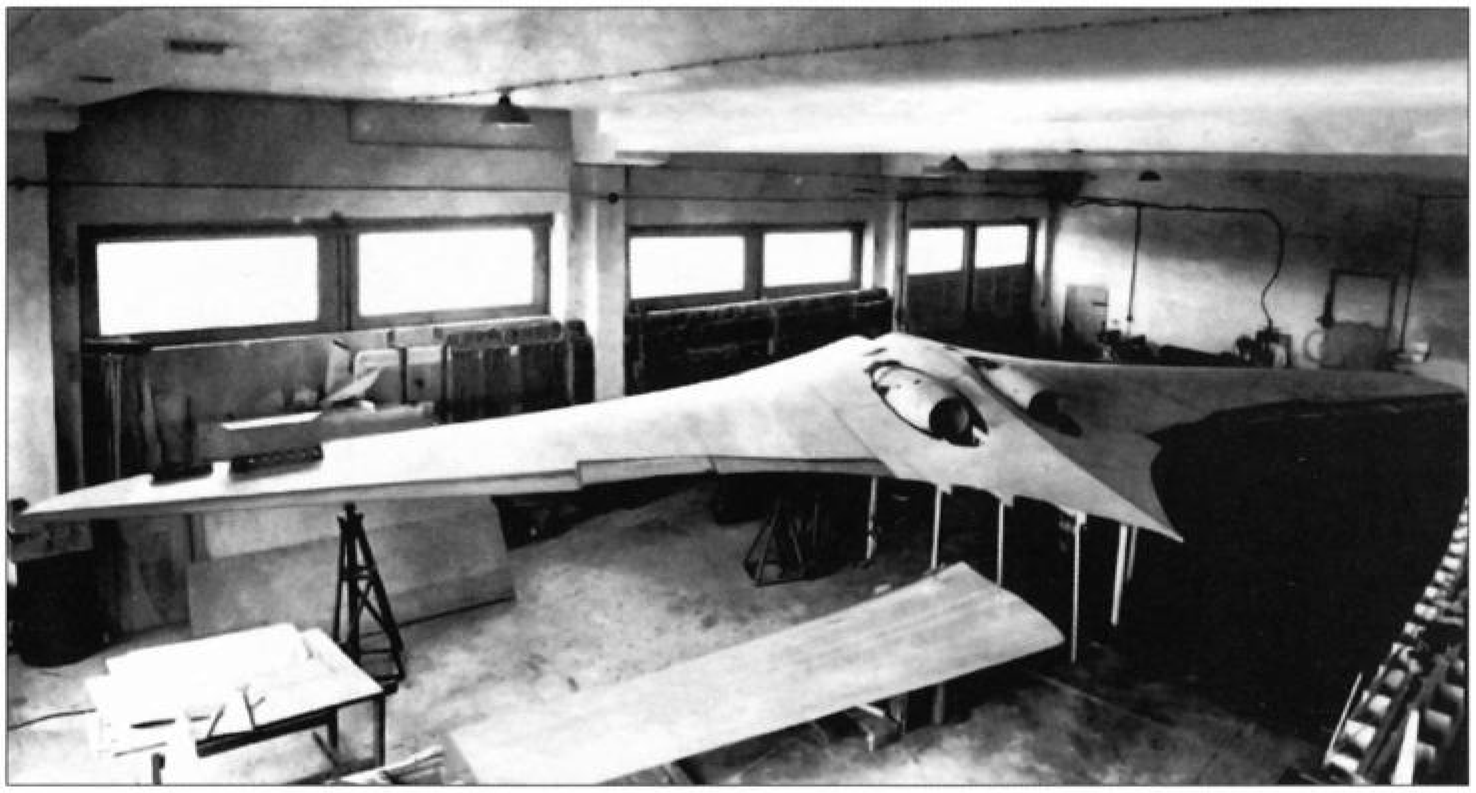


Walter (left) and Reimar Horten (right) were at the forefront of advanced flying wing design and both were tracked down in the immediate postwar period by US Intelligence as possible creators of the flying discs seen around the world, which were suspected of being Soviet aircraft. In the background of this photograph are the Horten Ho 11 (left) and Ho 111 gliders.
Courtesy of David Myhra

No mention of this radar-absorbing material (RAM) appears in early descriptions of the Go 229 and there are no references to tests that established the feasibility of configuring this design to avoid radar detection. That said, the Germans made considerable progress with radar countermeasures and perhaps their most significant achievement was the effective masking of U-Boat periscopes. So the idea of a Second World War German stealth fighter cannot be completely dismissed.

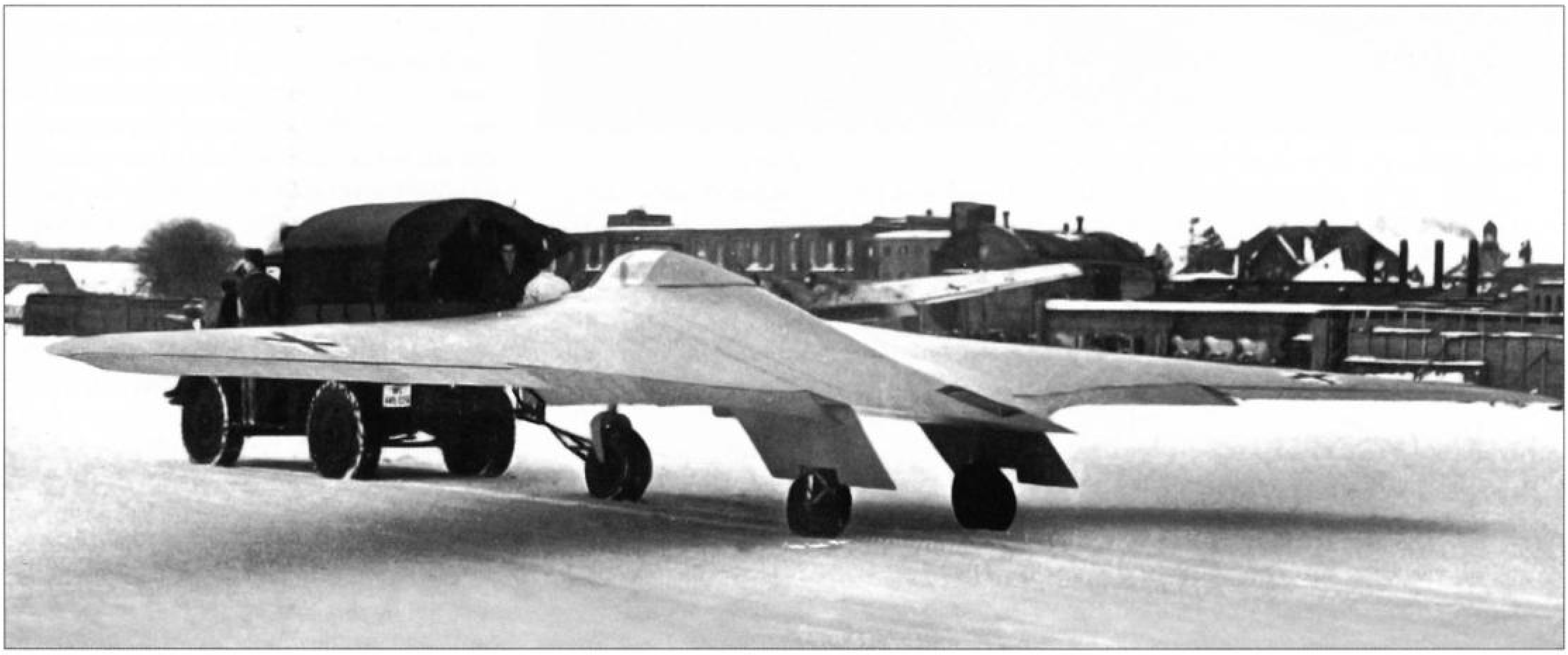
At the beginning of 1945 Gotha engineers working under the direction of Dr. Ing. Hünerjäger (who were responsible for producing the Go 229) completed plans for an advance flying wing fighter called the P.60A, which was accepted for further development by the RLM as a potential successor to the Go 229. This design was considered to be a big improvement over the Go 229 fighter by American scientists who examined the P.60A research material in some detail. However, the Hortens designed their own replacement for the Go 229 and this near-supersonic jet known as the Ho-X was expected to enter ser-



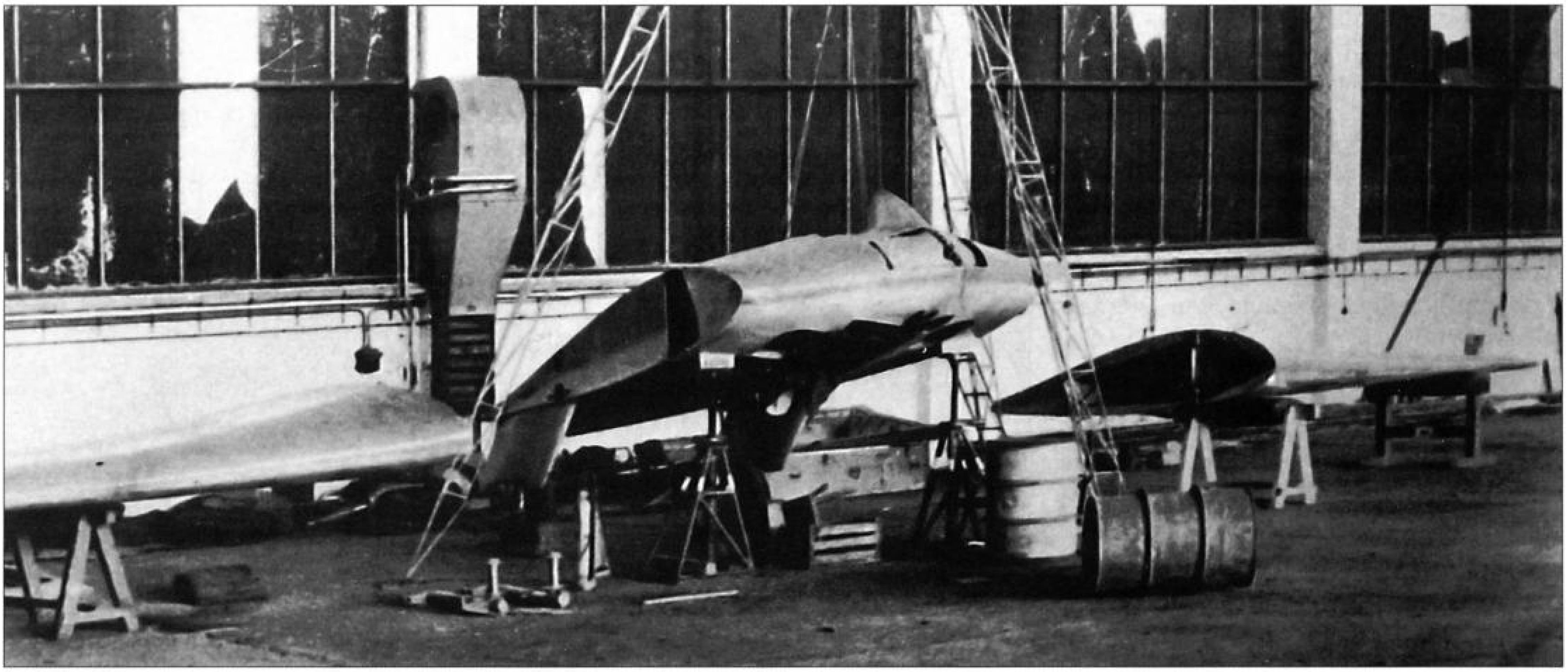


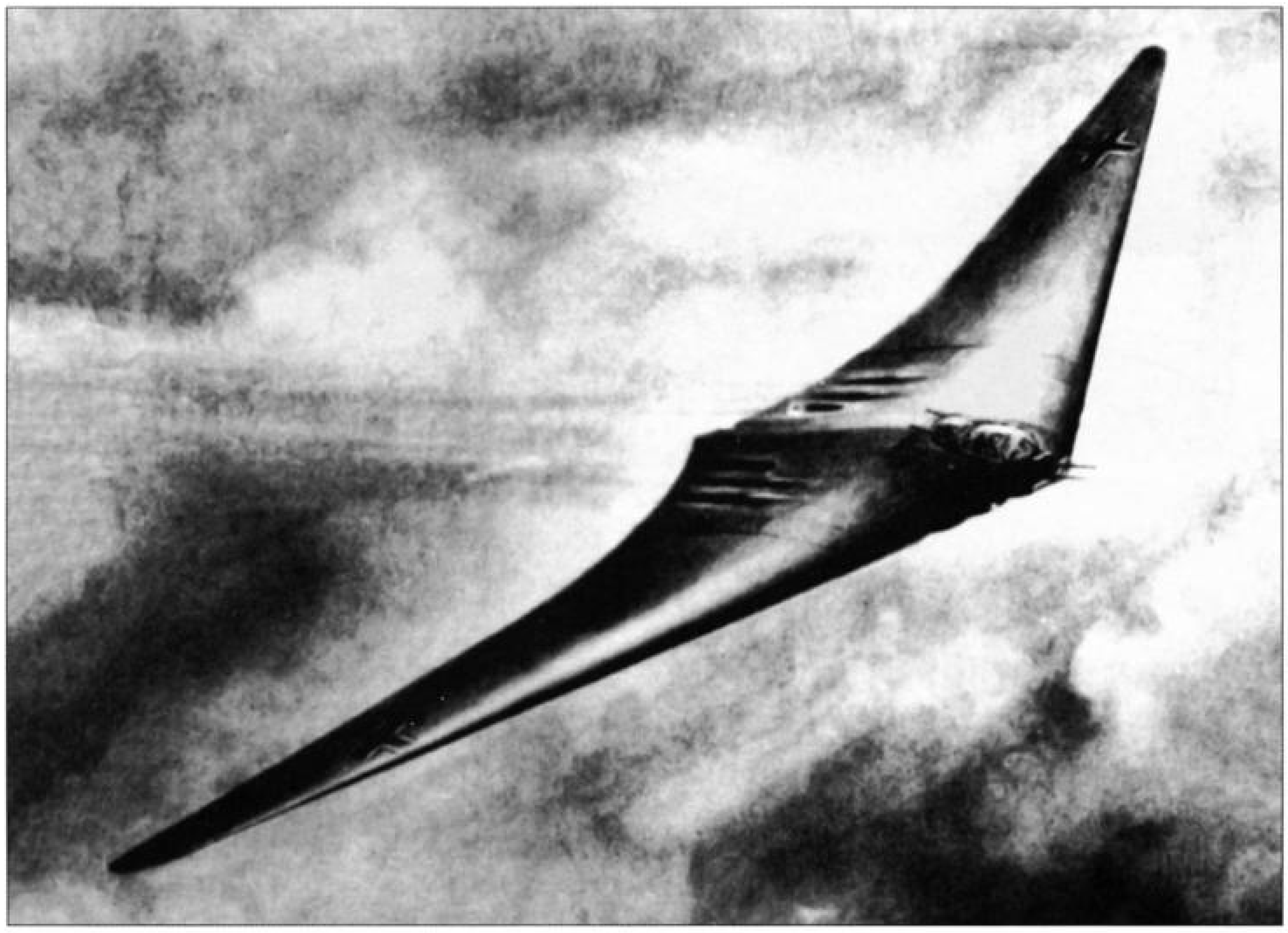
Horten Ho 9 V2 undergoing assembly in the workshops at Göttingen Airfield. Courtesy of David Myhra

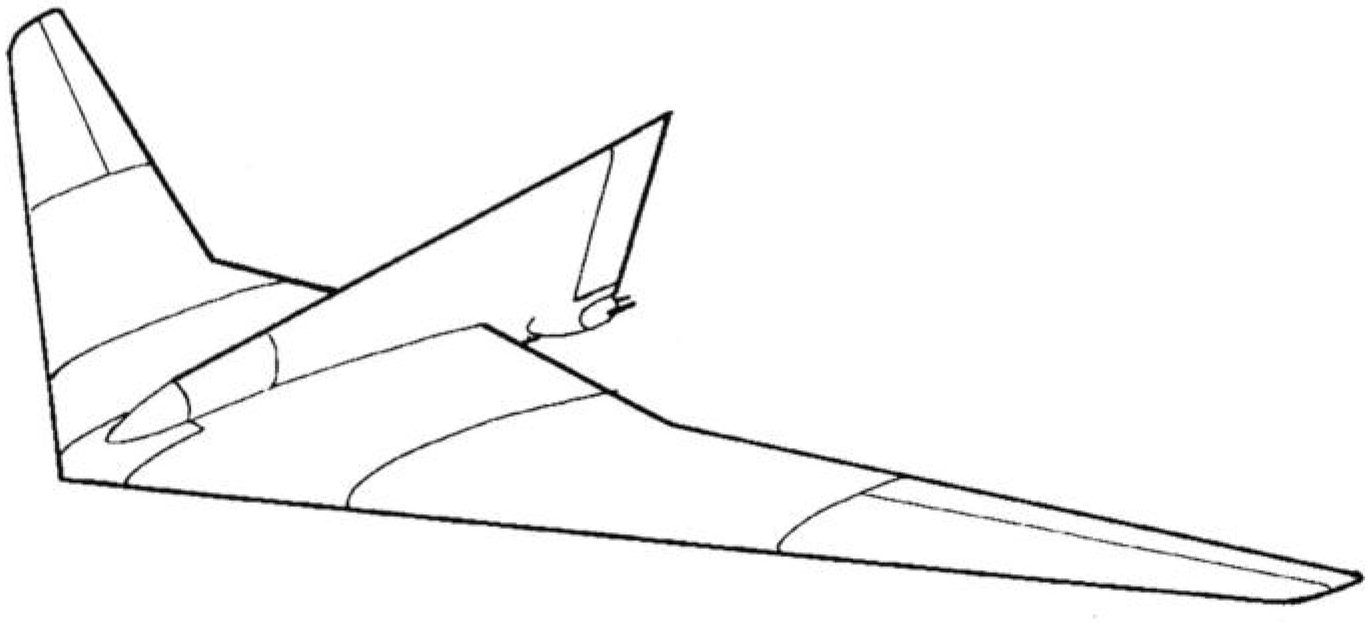
The experimental Ho 9 V1 glider designed by the Horten Brothers is moved by a ground crew in preparation for a test flight at Oranienburg Airfield, during mid-1944. Courtesy of David Myhra



The Horten Ho 9 VI is towed across a snow-covered airfield, probably in early 1944. Note the fixed rear wheels in streamlined fairings used on this initial prototype. After trials at Oranienburg, V-1 was moved to Brandis and finally destroyed by occupying US forces. Courtesy of David Myhra







The dismantled Horten Ho 9 V1 experimental glider, discovered by US military personnel at Brandis in May 1945 and subsequently destroyed. US Army

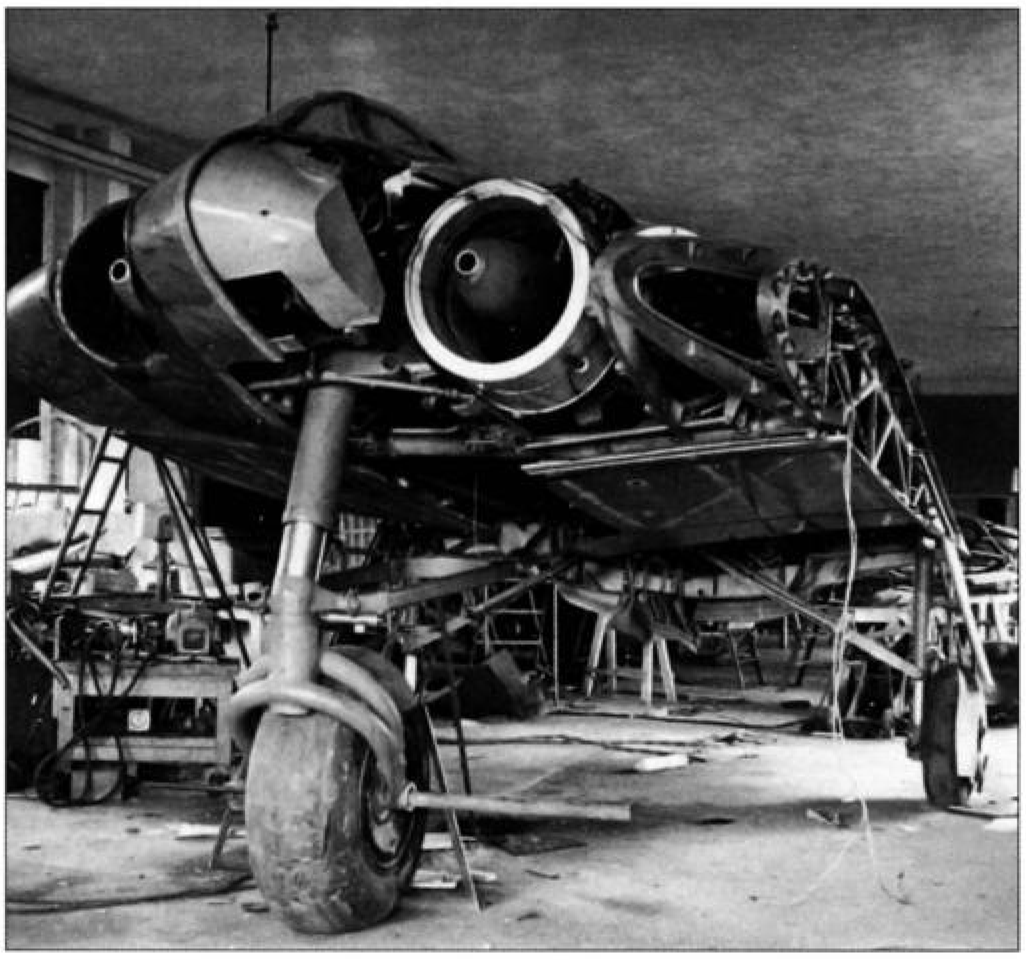
Artwork showing the proposed Horten Ho XVIII America Bomber, which bears a considerable resemblance to the modern Northrop-Grumman B-2A Spirit stealth bomber. via Bill Rose

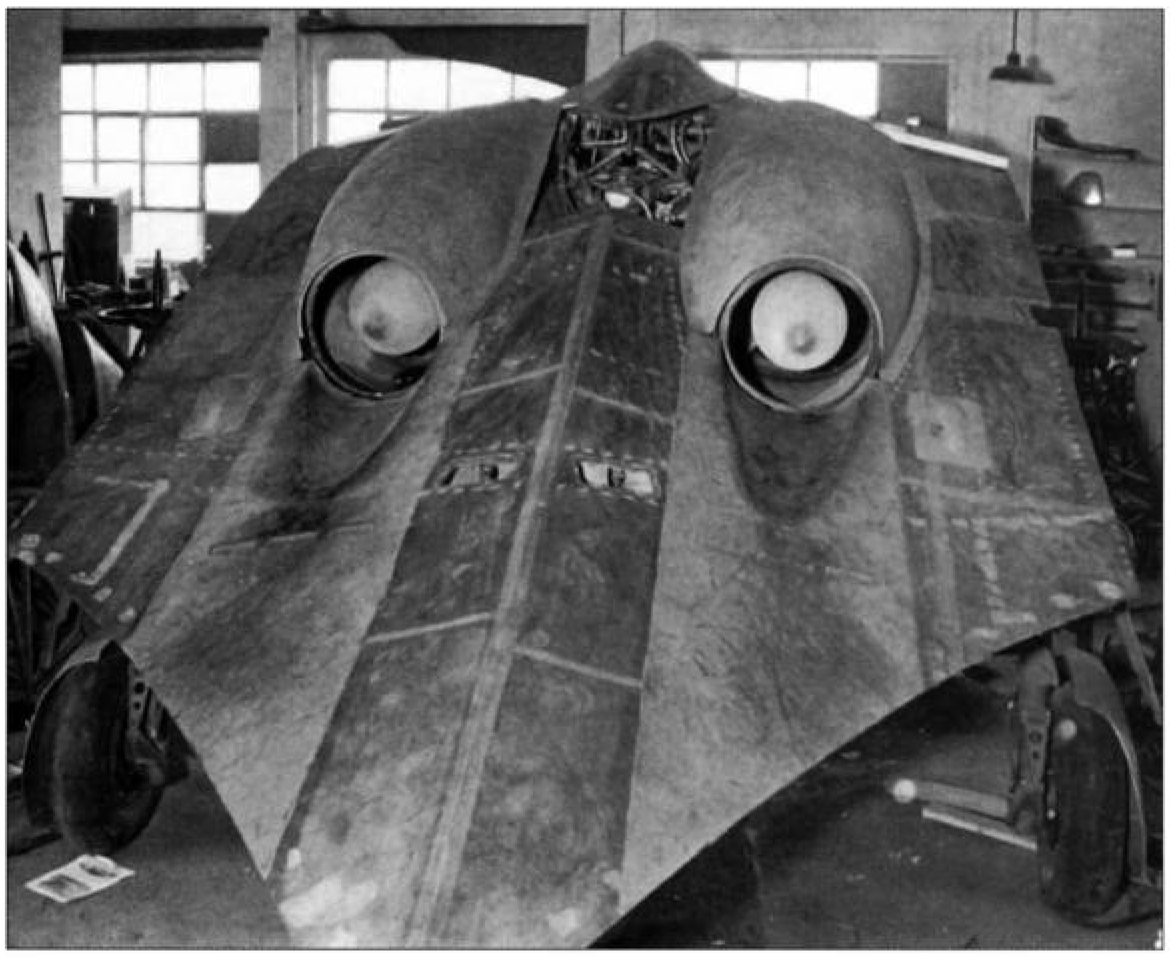
Second configuration for the Horten Ho XVIII America bomber. via Bill Rose

vice in 1946, being described as the next *Volksjäger* (People's Fighter).

The Hortens also worked on a series of jet bombers and the most interesting project was a long-range flying wing, capable of crossing the Atlantic. In early 1944 the RLM began to look at ways of attacking targets on America's eastern seaboard and they issued a requirement to several major design teams. The high-speed, high-altitude jet aircraft they required had to deliver four tons of bombs or possibly one atomic weapon (perhaps radiological) to the US East Coast and return from this 7,000 mile (11,265km) round trip without refuelling. The major aviation companies considered this challenge too great with prevailing technology, but the Hortens (who had not been approached to participate in the project) started to work on a flying wing concept, giving it the designation Ho XVIIIA Amerika Bomber.

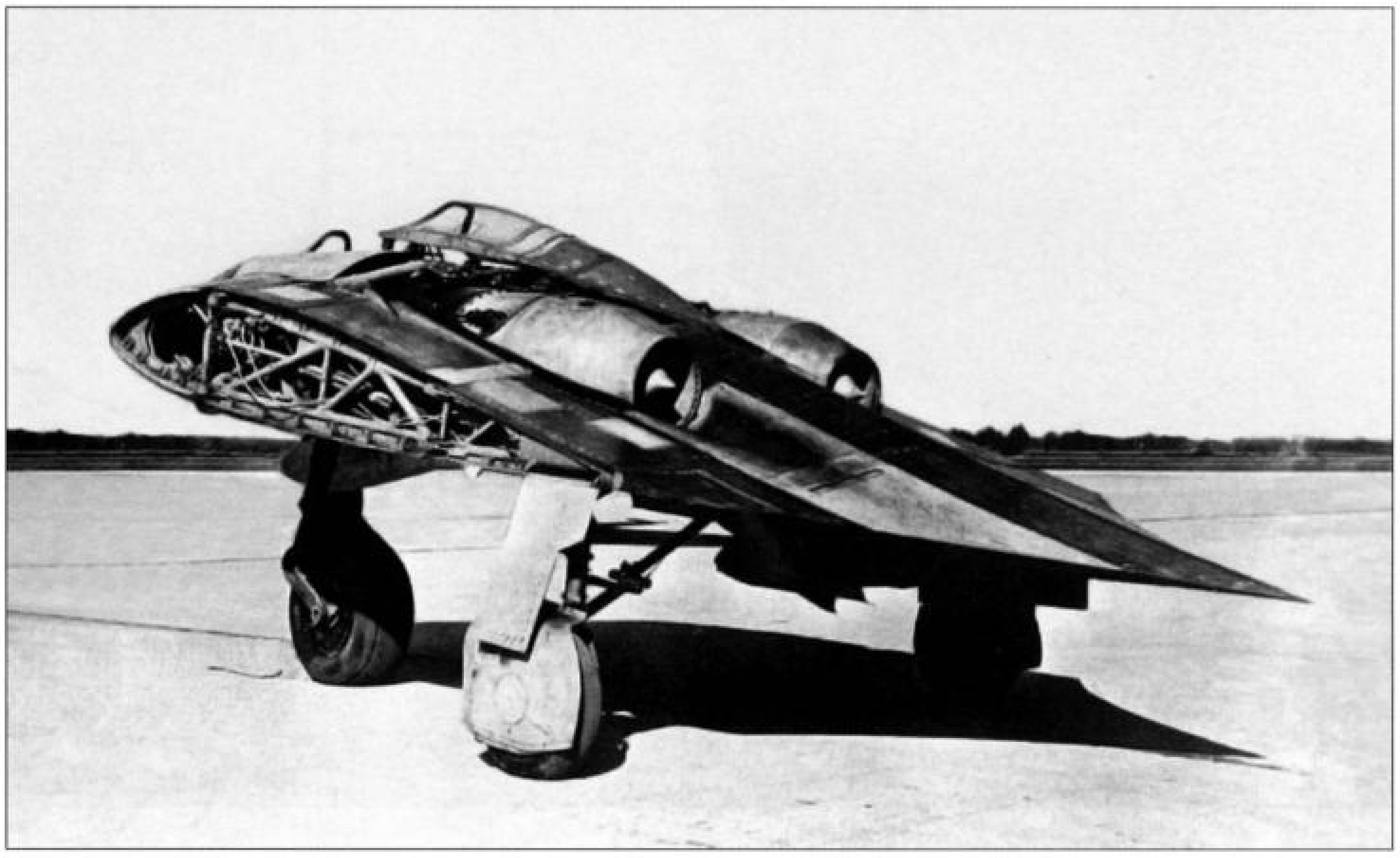
During January 1945 the Hortens completed several proposals for a flying wing Amerika Bomber, which only varied to any degree in their engine layout. Their stealthy aircraft would have possessed a 172ft (52m) wingspan, which surprisingly was about the same size as the Northrop XB-35 and YB-49





Top left: **Forward view of the largely completed Horten Ho 9 V3 flying wing jet fighter, which had almost been completed when it was discovered by members of the US 3rd Army VII Corps on 14th April 1945 at the Gotha works at Friederichsroda. The Ho 9 V3 (also known as the Gotha Go 229) was assigned the reference T2-490 and shipped by sea to the United States with other captured aircraft of interest. It was eventually passed to the National Air & Space Museum by the USAF.** USAF

Top right: **Rear view of the Horten Ho 9 V3 (Go 229) discovered by US forces at the Gotha works in an advanced stage of assembly. Had the war in Europe lasted longer, these aircraft would have entered service with I/JG 400 at Brandis, replacing their Me 163B Komet rocket fighters.** USAF



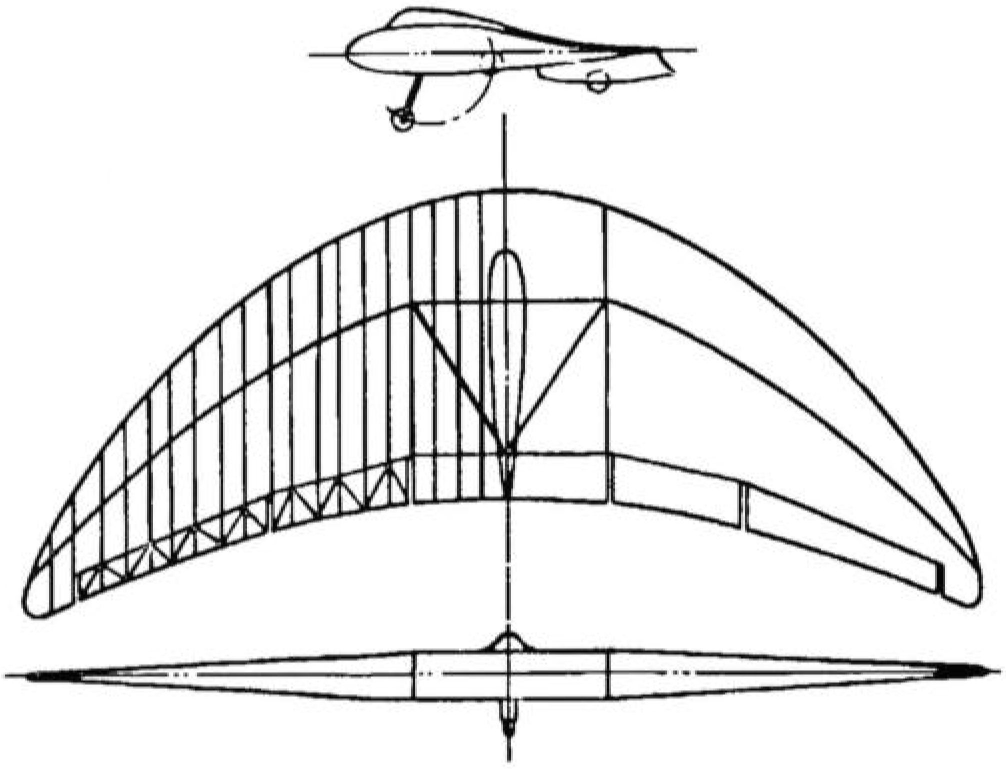
Right: **The Horten Ho 9 V3 prototype flying wing jet fighter (minus its wings), which was discovered with several other partly completed Horten prototypes by US forces at the Gotha works on 14th April 1945.** USAF

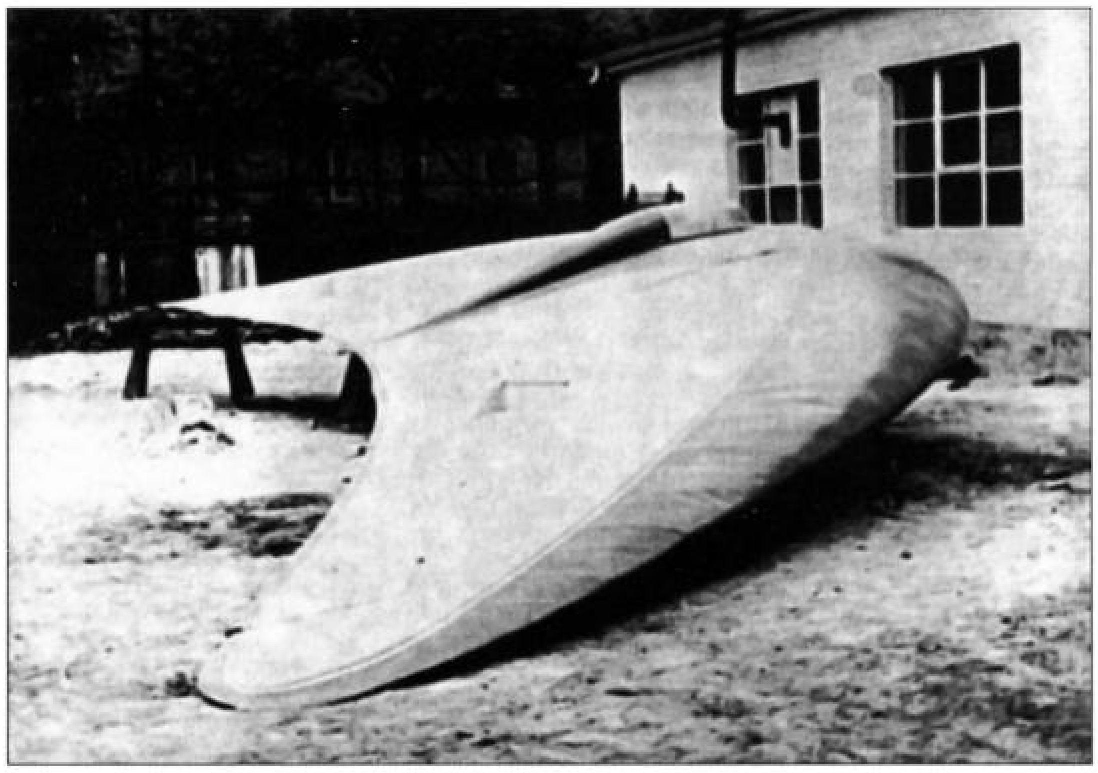
bombers and the current Northrop-Grumman B-2A Spirit. After the design had been submitted in February 1945, Reichsmarschall Goering gave his immediate approval and assigned Junkers to begin construction at the earliest possibility.

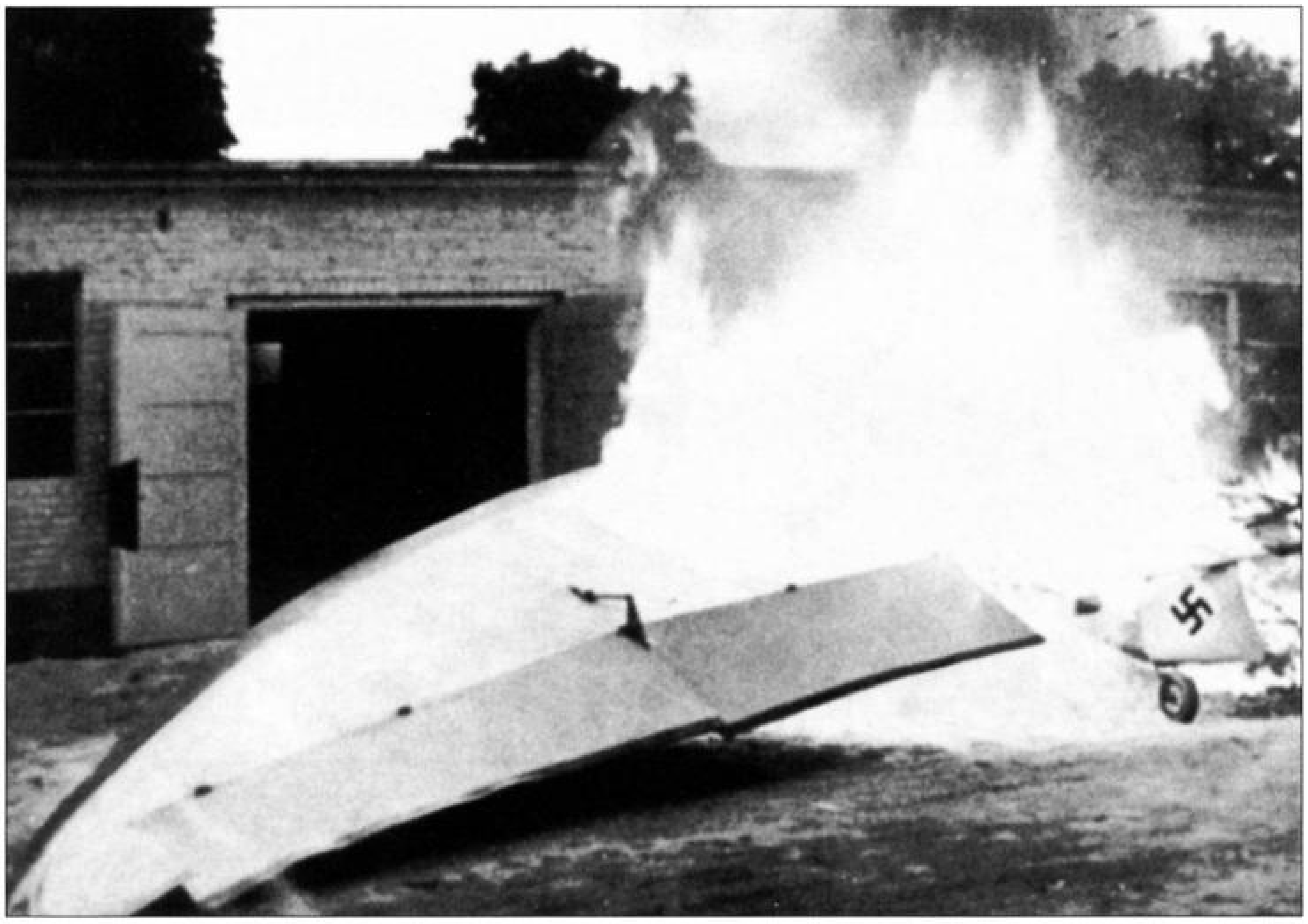
Following further design revisions, the Hortens completed blueprints for the Ho XV111B and it was decided that assembly of the first two prototypes would start immediately in massive underground facilities near Kala, where new runways for the aircraft were already being built. While it seems that this project progressed no further, there have been reports that engineers started work on the first airframe. Few Horten aircraft survived the War and ground staff intentionally destroyed most examples. However, some Go 229 variants in various stages of assembly were found at the Gotha factory near Friedrichsroda, which was initially secured by US forces and then passed to the Russians. The Americans managed to remove Go 229 V3 before the handover took place and this aircraft is currently stored at the National Air & Space Museum, where it has been allowed to seriously deteriorate. At least two other Horten jets were shipped to Russia, along with large quantities of components and technical information.

There have been many allegations that the Hortens were heavily involved in the development of circular-winged aircraft. The brothers were certainly responsible for the design and construction of a parabola-shaped glider, but it never flew and was finally scrapped. However, it is possible that a secret (and still unacknowledged) development of the parabola design was undertaken during the War.

Slight evidence of this came to light in 2004 when several apparently genuine declassified USAF documents from 1948 were located. They are marked MOIC Headquarters, CIC Region 1, File 1-1606 and mention is made of Operation HARASS. Crude drawings show a very advanced rocket-powered fighter, which is almost horseshoe-shaped and the design is attributed to the Horten Brothers. It seems reasonable to assume that the aircraft was intended to be a supersonic high-altitude interceptor. The aircraft was configured to carry a prone pilot in a central capsule with rocket engines at each wingtip. The overall length of the aircraft was 68ft 10in (21.0m), it had a span of 46ft (14.0m) and it would land on a central extended skid.







Horten Parabola

Type	Experimental glider
Accommodation	One
Propulsion	None
Max speed	101mph (163km/h)
Landing speed	18mph (29km/h)
Stall speed	18mph (29km/h)
Wingspan	39ft (11.9m)
Empty weight	198lb (90kg)
Max weight	374lb (170kg)
Construction	Steel tubing and wood

Notes

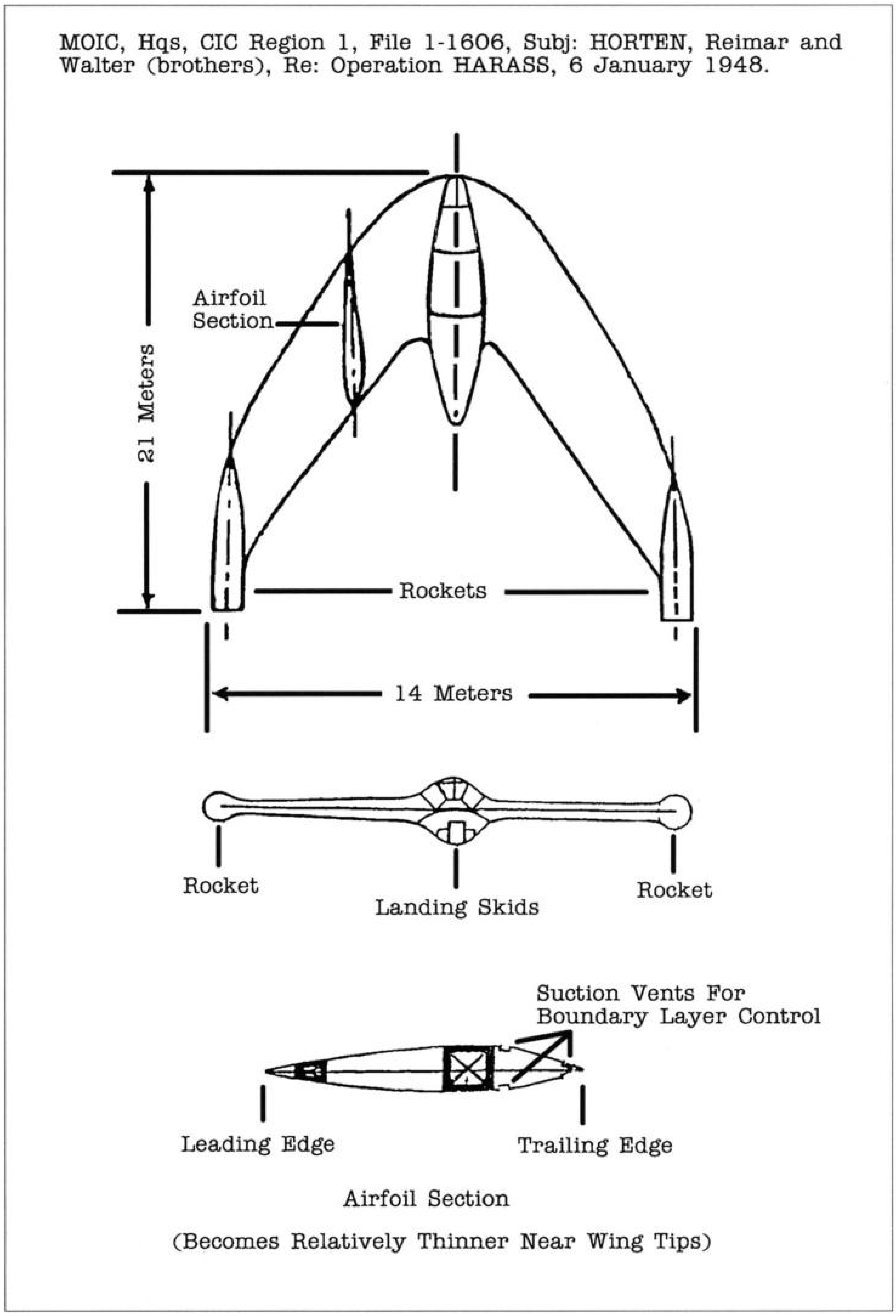
Built at Aegidienberg near Koblenz in 1938, this very light sailplane was never flown, having been badly damaged during storage. It was not considered repairable and the Parabola was finally set on fire and completely destroyed.

The wing shape is particularly unusual, with a very thin leading edge increasing in width to a thicker section towards the trailing edge that contained boundary layer extraction vents. This might be an attempt to improve stability at lower speeds, as this unusual wing design would present many aerodynamic problems. Nothing more is known about this alleged Horten design and it could be a post-war concept, perhaps even an attempt by Reimar Horten to show the type of experimental aircraft that might have been responsible for the Kenneth Arnold UFO sighting on 24th June 1947. Coincidentally, the Soviet aircraft designer Boris Ivanovich Chyeranovskii designed and built a series of small parabola-shaped aircraft between the wars (see Chapter Five) and, conceivably, the Hortens were aware of his work and this inspired their Parabola design.

At the close of hostilities both brothers were recruited by the British and transported to London on 9th May 1945, where they were extensively debriefed. The Horten brothers were considered by the British to be argumentative, slightly eccentric and difficult to get along with. Reimar was sent to work at Fairey Aviation in England but, according to one report, the company's design staff would not associate with any Germans and the situation became very tense. Official records show that the Horten brothers were then returned to Göttingen and, while Walter looked for employment, Reimar gained a doctorate in mathematics at the University of Bonn. (Walter apparently, continued to receive money from British Intelligence, a situation that has never been acceptably explained.)

In early 1947 Walter married Fraulein von der Groeben, who had been secretary to General Udet. Walter Horten then approached American flying wing guru Jack Northrop seeking employment with his company. Northrop was very keen to have both brothers on his staff and suggested to Walter that he should contact the USAFE in Wiesbaden to make arrangements for service in America under *Operation Paperclip*. But nothing came of this and it seems that the Americans were not interested in securing the services of these two brilliant aeronautical designers, despite the fact that large USAAF teams and many contractors were engaged in analysing the Hortens' research work.

Paradoxically there is a declassified USAF document, dated 30th October 1947, from General George Schulgen (who headed the Intelligence Requirements Office) that dis-



MOIC, Hqs, CIC Region 1, File 1-1606, Subj: HORTEN, Reimar and Walter (brothers), Re: Operation HARASS, 6 January 1948.

Full document showing high-altitude rocket-powered interceptor said to have been designed by the Horten brothers. via Bill Rose

Photographs on the opposite page:

Top left: **Drawing of the Horten Parabola, which was built as a glider but never flew.** US Army

Top right: **Horten Parabola glider, which was damaged during transit and never flown. This design may have led US Intelligence to conclude that the Horten Brothers were involved with flying disc design.** Courtesy of David Myhra

Left: **Horten Parabola glider, deliberately set on fire at Göttingen after it was decided that the aircraft was beyond repair.** Courtesy of David Myhra

cusses UFOs in some detail. He goes on to suggest that the Horten Brothers might be responsible for designing some of the unidentified flying discs seen around the world. Schulgen said, 'What is the present activity of the Horten brothers, Walter and Reimar? What is known of the whereabouts of the entire Horten family?' He then asked, '[has there been] any interest shown by the Russians to develop their [Horten] aircraft? Are any efforts being made to develop the Horten 'Parabola' or modify this configuration to approximate an oval or disc?'

Why did the USAF continue to express great interest in the Hortens, when they were giving them the cold shoulder? There seems no clear answer to this strange situation. Could there simply have been a total lack of communication between different US agencies, or was something else taking place behind the scenes? According to official documents, the 970th Counter Intelligence Command finally located the Horten Brothers during March 1948, interviewed them and 'collected all the desired information', bringing their enquiries to an end! Whatever the truth about this mysterious episode, Reimar Horten then moved to Argentina, where he married a German glider pilot called Gisela Hilger. In the years that followed, he worked on experimental aircraft for the Argentine Government and completed a few prototypes, but the lack of funding and poor technical support made these endeavours a complete waste of time.

Throughout this period, US Intelligence specialists continued to suggest that Soviet aircraft developed from Horten designs might explain a number of recent UFO sightings and this theory was discussed in Technical Intelligence (T-2) Report No 100-203-79, dated 28th April 1949. Another US Intelligence report suggested that the Soviets were preparing to build a huge fleet of flying wing bombers, based on the Horten XV111 design, which would rival the forthcoming Northrop B-49 in performance. Perhaps there were good grounds for these fears because Dr Gunther Bock, who had been placed in overall charge of Germany's special aircraft research groups (including Sonderkommando 9), was captured by the Soviets on 29th April 1945 and put to work on secret military aviation projects for the Red Air Force.

Nothing is currently known about Bock's work in the Soviet Union, although large fleets of Soviet flying wing bombers never materialised. On the other hand, several postwar US 'Black Budget' aircraft may have been developed using the Horten Brother's research: one known proposal was the long-winged stealthy Gusto high-altitude spyplane that was conceived by Lockheed's Skunk Works and progressed to model form. While Jack Northrop was already established as America's leading advocate and designer of the flying wing, there can be little doubt that his postwar work was strongly influenced by the Horten Brothers.

Canada's Cold War Saucers

As relations with Communist countries worsened during the early days of the Cold War, Pentagon planners turned their attention towards advanced aerospace projects, hoping these would provide a valuable edge in any future confrontation. The Americans anticipated spaceplanes carrying nuclear weapons, high-performance spyplanes capable of cruising through the stratosphere and fleets of supersonic flying discs designed to protect the homeland against sneak air attacks. With defence dollars flowing like water and low labour and material costs, this allowed many *avant garde* proposals to be developed into experimental hardware that sometimes reached the testing stage, and in a few cases led to useful weapon systems.

Inside the Pentagon concerns were growing that Russia would capitalise on the most advanced aerospace technology captured from the Nazis. This would provide them with high-performance jet fighters, long-range strategic bombers and, eventually, intercontinental ballistic missiles. It was also apparent that Western traitors had provided the Soviets with enough technical information to fully develop an atomic bomb and this adjustment of power in favour of the Communists sent shudders through the Pentagon and ratcheted up tension between the superpowers. While the Russians would take years to develop a strategic nuclear missile force, it seemed certain that any large-scale attack on the United States would be undertaken by aircraft crossing the Pole.

Initially, the Soviet bomber threat was more of a worry that a reality and the only effective type flown by the Red Air Force was a Tupolev copy of the Boeing B-29 called the Tu-4 *Bull*. But the CIA had obtained some details of Russia's future strategic bomber programme, which was based on the significantly more advanced Tupolev Tu-95 *Bear* and the Myasishchyev M-4 *Bison*, both of which had reached the prototype phase by 1952. From the American and Canadian viewpoint this bomber threat was made worse by the fact that their northern air defences were totally inadequate and would remain that way for some time to come.

Early post-war jet fighters lacked performance, surface-to-air missiles were still in their infancy and the patchy northern radar network, rather appropriately called the Lashup system, utilised fairly primitive and somewhat unreliable World War Two technology. There were plans for a chain of US-Canadian radar stations, but this would take many years to complete and the project didn't even get off the ground until 24th February 1954 when President Eisenhower approved the National Security Council's request to construct the Distant Early Warning or DEW Line.

Soviet Tu-95D *Bear* on a long-range reconnaissance mission intercepted by an F-4 Phantom. The *Bear* was one of the first long-range Soviet bombers to threaten America's mainland. US Navy

Subsonic all-weather fighters were starting to enter USAF and RCAF service, but there were fears that by the time these aircraft had been deployed in sufficient numbers the Russians would be operating more advanced bombers.

Across the Atlantic, RAF Intelligence were echoing these concerns, with predictions that by 1960 the Soviet Union would possess Mach 2 strategic bombers capable of cruising at altitudes in excess of 60,000ft (18,288m). This generated Air Staff Operational Requirement (OR) 301, which in turn led to a number of proposals forwarded by UK contractors for supersonic jet/rocket-powered interceptors.

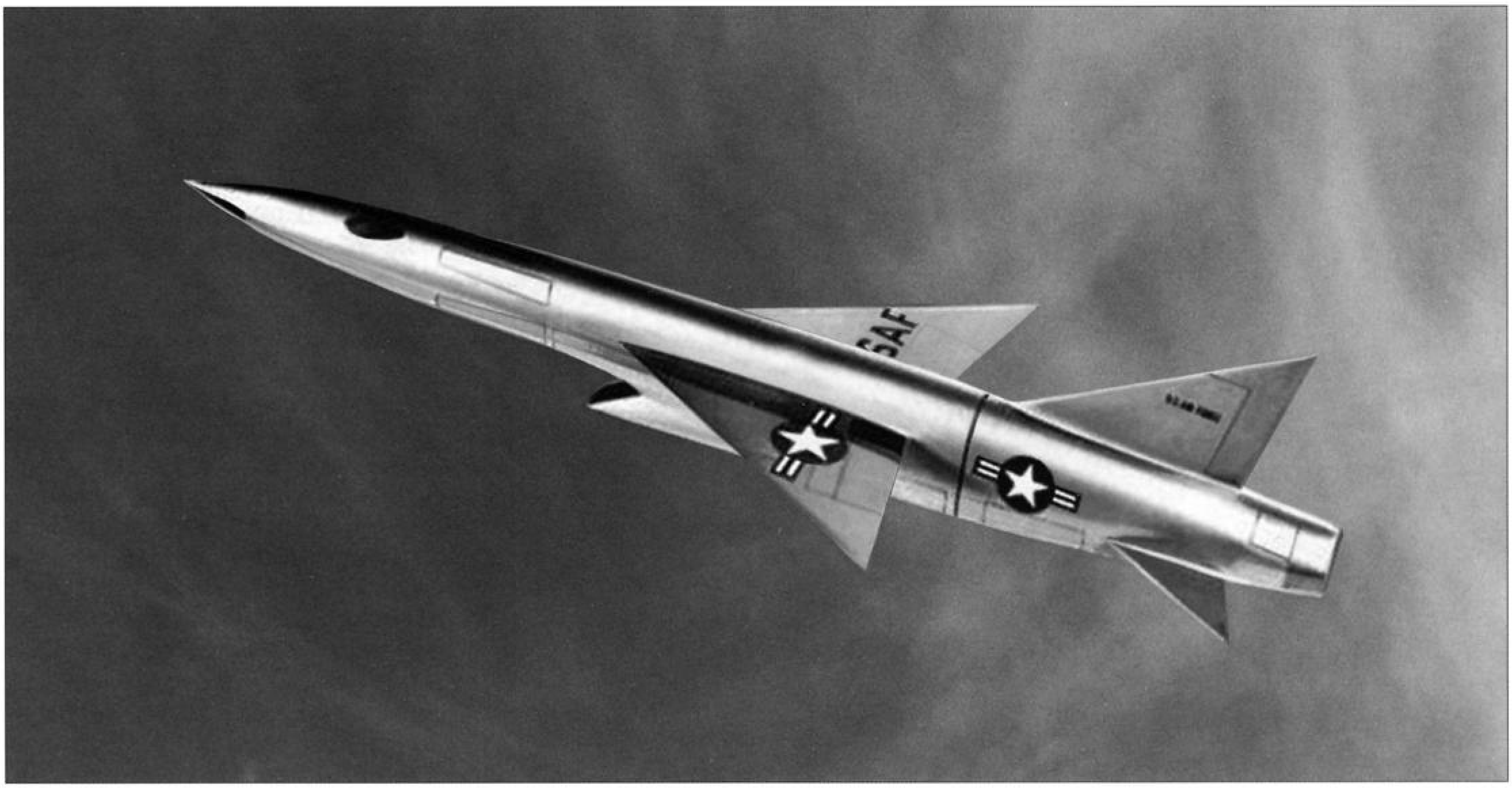
The Saunders-Roe SR.53 and Avro 720 became the leading candidates and were selected as the designs to be produced in prototype form. However, in 1955 the Avro 720 was dropped, while the SR.53 was eventually completed and flown purely as a research aeroplane for the mixed rocket-jet powerplant combination. By now Saunders-Roe were working on the more advanced P.177 to OR.337, which had become the planned production aircraft intended to fill the requirement, but it never flew and rocket-propelled fighters were finally found to be impractical. Nevertheless, the high-altitude bomber threat remained a serious concern, which was eventually countered by the RAF's supersonic English Electric Lightning fighter. Instead of rockets this had very powerful jet engines fitted with reheat, which enabled it to reach high altitudes very quickly.

The Americans approached the threat to their northern territory by funding a whole series of studies that began in late 1949 for a supersonic interceptor capable of dealing with any anticipated Soviet bomber developments. There were nine submissions from major contractors to the MX 1554/WS-201A requirement and the choice was then narrowed down to designs from Consolidated Vultee (later Convair), Lockheed and Republic. The USAF finally selected Republic's AP-57 proposal for a very exotic high-altitude Mach 3.7, turbo-ramjet-powered interceptor and this received the official designation XF-103. At the same time Convair's delta-winged design, based on research undertaken by Dr Alexander Lippisch, was revised and also received the green light, eventually becoming the lower-performance F-102A Delta Dagger.

In 1951, the USAF ordered two prototype XF-103s with airframes built from exotic titanium alloy, but development was painfully slow. Although there were some major technical challenges for Republic's design team lead by Alexander Kartveli (who had been responsible for the P-47 Thunderbolt) most of the issues concerning the XF-103 manned

Saunders-Roe SR.53. The RAF's choice for development of a high-performance mixed-propulsion interceptor to counter the anticipated Soviet bomber threat. Saunders-Roe via Bill Rose

Saunders-Roe SR.177 proposed mixed-propulsion interceptor to counter the expected Soviet bomber threat. Saunders-Roe via Bill Rose



Republic's XF-103 turbo-ramjet interceptor was the USAF's high-tech solution to intercepting Soviet bombers crossing the North Pole. This advanced project was never completed. via Bill Rose

Voodoo and Starfighter interceptors. Both American aircraft eventually entered service with the RCAF to defend the north against the Soviet bomber threat. USAF

missile were eventually resolved, but the project finally met with abrupt cancellation on 21st August 1957.

This was the year when Western governments declared that the manned fighter was obsolete and a number of cutting-edge projects fell by the wayside before common sense prevailed. However, by this time several advanced but slightly less ambitious US supersonic fighter programmes had become established: these included the USAF's Convair F-102A, the twin-engined McDonnell F-101 Voodoo and the single-engined Lockheed F-104 Starfighter. The two latter fighters would enter RCAF service in the early 1960s as the CF-101B and CF-104.

But back in 1951, the Canadian Government aspired to its own next-generation supersonic interceptor that was able to operate from low-grade scattered sites in northern parts of the country. This requirement for aircraft dispersal had already influenced the design of the RCAF's Avro Canada CF-100 Canuck, which could take off from a rough airstrip that was no more than 4,000ft (1.21km) in length. Canada's aerospace industry had great potential for expansion and the Government believed that Canadian companies would eventually lead the world in terms of advanced technology and innovation.

Confident that sufficient expertise was available, the Canadian Defence Research Board (CDRB) decided to approach Avro Canada Ltd at Malton, Toronto (a subsidiary of A V Roe & Co Ltd, Manchester, England and part of the Hawker-Siddeley Group), with their requirements for a supersonic interceptor capable of meeting the Soviet challenge. They realised that a new interceptor would need to remain effective well into the next decade and this RCAF air defence requirement finally led to a concept called Project Y, which was fully supported by the British parent company and secretly backed by Whitehall and the Pentagon.

Unannounced British involvement and US interest in Project Y was hardly remarkable in light of the close ties and shared defence interests of the three countries. Sir Roy Dobson, who controlled Avro UK, was in regular contact with CDRB Chairman Dr Ormond. M Solandt, who had been Superintendent of the British Army's Operational Research Group during World War Two. A personal link also existed between Dr Solandt and the Pentagon's weapons technology expert Dr Vannevar Bush who headed the Joint Research and Development Board and it has been said that members of Dr Bush's team would regularly attend closed CDRB meetings on an informal basis. Once the decision to proceed with Project Y had been taken, the CDRB allocated $410,000 for start-up studies and additional funds were provided by Avro Canada, who appointed the quietly spoken Englishman John Carver Meadows Frost as Project Y's director.

Project Y

John Frost CEng FCASI, MRAes (1915-1979) was a talented British aircraft designer who was born on 30th November 1915 at Walton-on-Thames. He received his education at St Edwards School, Oxford and shared an interest in aviation with the school's Latin teacher, who took him on his first flight in 1930. Frost's teacher (a qualified pilot) flew the Bristol aircraft in weather conditions that are said to have been rather poor. Apparently, the 15-year-old Frost couldn't stop vomiting, although it did little to dampen his enthusiasm for aviation. Nevertheless, he would be troubled by airsickness throughout his life.

Frost began his aeronautical career as an apprentice with Airspeed Ltd, then joined

John Frost at a meeting with US General Trudeau. via Bill Rose

The second de Havilland DH.108 Swallow Experimental jet aircraft (TG306), which John Frost worked on before joining Avro Canada. The aircraft was destroyed in an accident over the Thames Estuary on 27th September 1946 when the airframe became structurally overloaded at a speed of about Mach 0.9, killing the test pilot Geoffrey de Havilland. de Havilland Aircraft Company, via Bill Rose

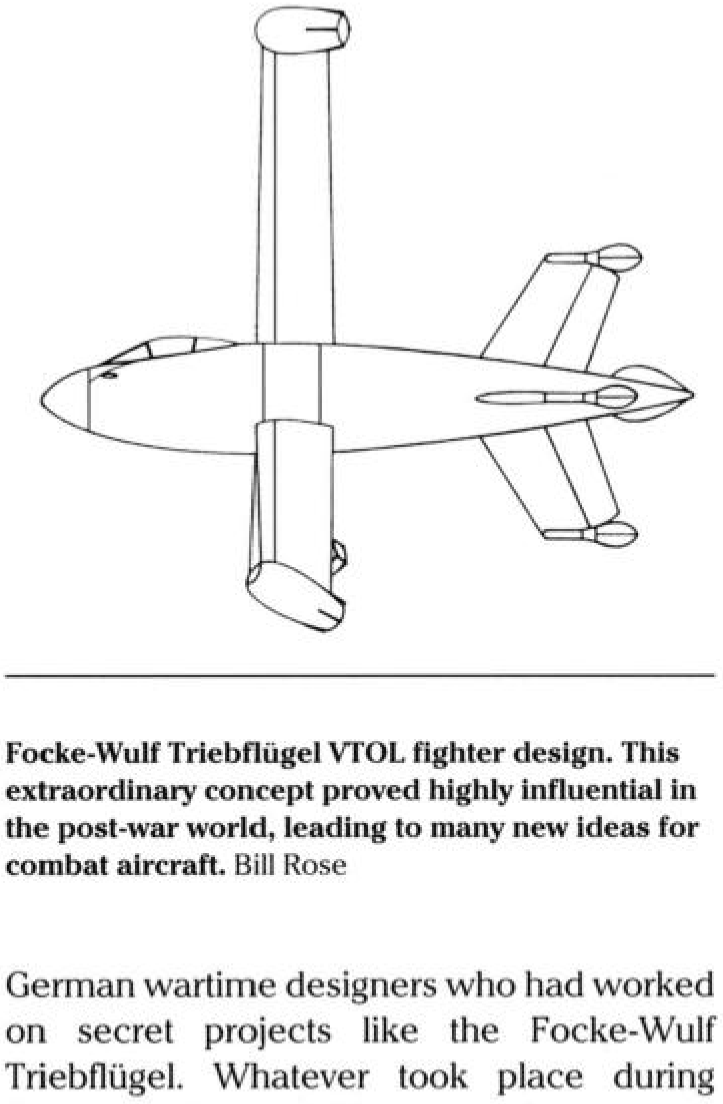
Miles Aircraft at Reading and moved to Westland Aircraft in 1936 where he worked on the twin-engined Whirlwind fighter-bomber, which entered RAF service in 1940. After spending two years with Blackburn Aircraft at Brough in Yorkshire, where he was primarily involved with their new wind tunnel, Frost joined Slingsby Sailplanes where he designed the Hengist troop-carrying glider. The Hengist was a sophisticated design, but the Airspeed Horsa was finally selected by the military on the grounds of lower cost and easy assembly.

After meeting his future wife Joan (who worked in Slingsby's Tracing Office) Frost moved to de Havilland at Hatfield in 1942. During the next five years he worked for R E Bishop on the highly successful multi-role wooden Mosquito, the Hornet, the DH.100 Vampire jet fighter and the experimental DH.108 Swallow. This advanced tailless swept-wing research aircraft was based on the Vampire, although it drew heavily on wartime research conducted by Dr Alexander Lippisch for the Me 163B Komet and his proposals for the more advanced jet-powered Messerschmitt P.1111 (which never reached construction). It was hoped to gather data on swept-wing design during trials of the DH.108 that could be used for programmes like the DH.106 Comet jet airliner and the DH.110 all-weather jet fighter (which eventually became the Sea Vixen).

Bishop's team had commenced work on the Swallow during October 1945 using the Vampire's fuselage as a starting point and they completed the first of three elegant-looking prototypes (to fulfil Air Ministry Specification E.18/45) by spring 1946. This shows just how quickly a new design could be built in those days. Frost personally tested the ejection seat for the Swallow and he was launched up a 60ft (18.3m) tower, which was quite an achievement for a man who was blighted with airsickness. Unfortunately, the Swallow programme received a major setback when Geoffrey de Havilland was killed in the second prototype, which suffered a structural failure during a test flight above Egypt Bay in Kent on 27th September 1946. However, on 6th September 1948 the third DH.108 would become the first jet-powered aircraft to exceed Mach 1.

Shortly after the accident that killed de Havilland, Frost married Joan and during this period he reportedly came into contact with German wartime designers who had worked on secret projects like the Focke-Wulf Triebflügel. Whatever took place during these meetings would seem to have generated a major interest in VTOL aircraft and Frost is known to have completed a number of private studies for helicopters powered by rotor tip jets.

After his first son Christopher was born in 1947, Frost accepted an offer from Avro Canada to become their Design Manager for



Focke-Wulf Triebflügel VTOL fighter design. This extraordinary concept proved highly influential in the post-war world, leading to many new ideas for combat aircraft. Bill Rose

Left: **Avro Canada CF-100 all-weather jet fighter. John Frost was recruited to head the design team for this aircraft in 1947.** RCAF

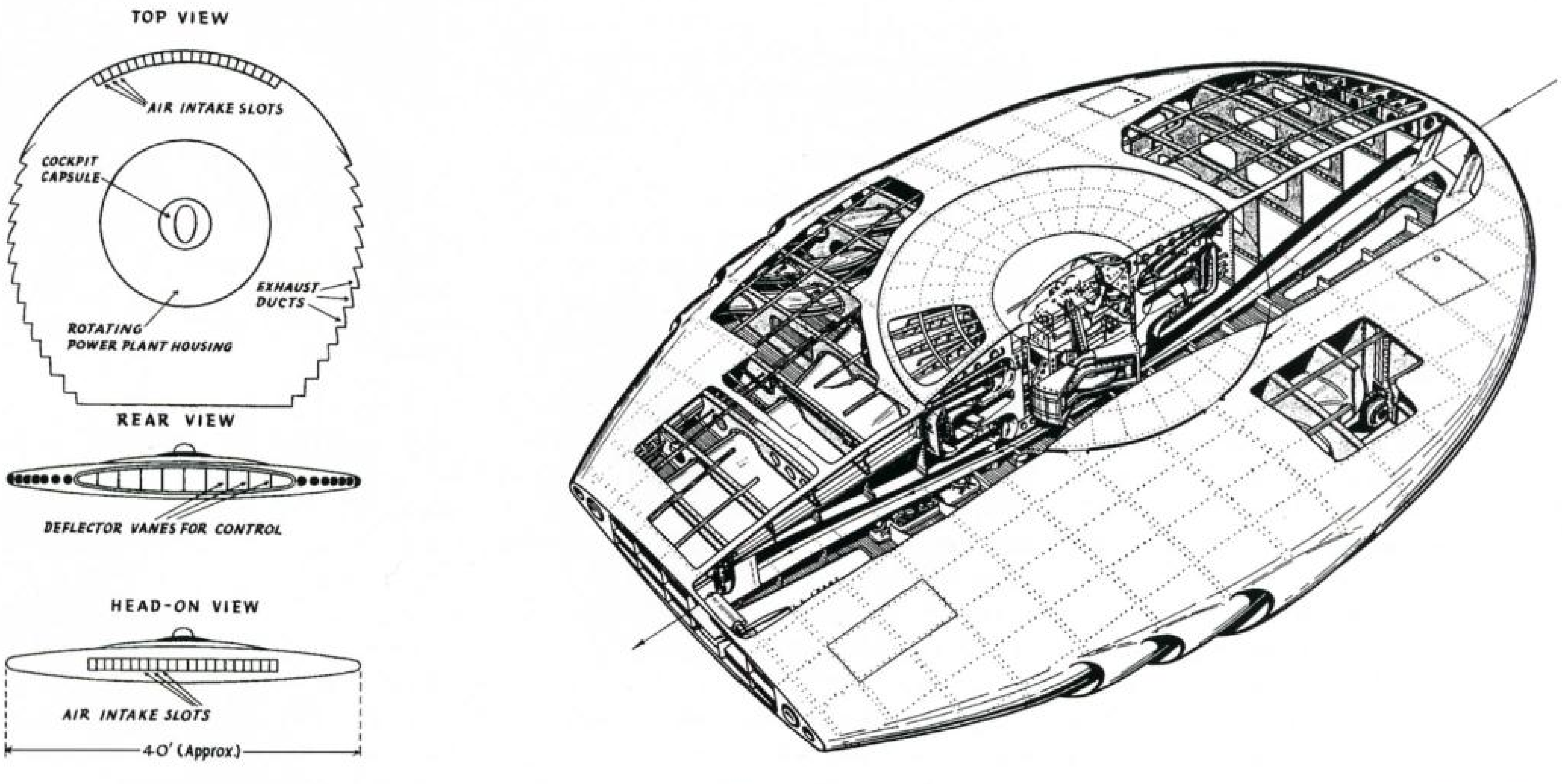
the CF-100 fighter programme. It seems there were problems with this aircraft and Frost would later admit that he didn't like the CF-100 very much. He once referred to it as a 'clumsy thing ... all brute force'. But, that said, Frost corrected the aircraft's shortcomings and began work on an improved swept-wing variant, although this was never built and Avro Canada soon moved on to the highly advanced CF-105 Arrow.

In 1951, Frost was appointed as head of Avro Canada's secret Special Projects Group (SPG) and the following year he and his family were asked to take out Canadian citizenship, which was a standard procedure for all defence workers born overseas. With a brief to start designing a supersonic daylight VTOL interceptor called Project Y, John Frost recruited aerodynamicists Thomas Desmond Earl and Claude John Williams for his team.

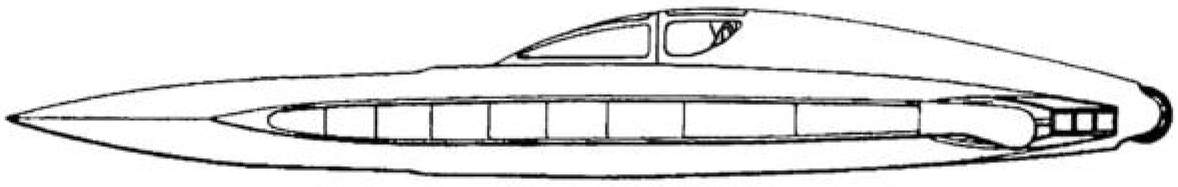
Initially, Frost's small group of about eight designers and engineers considered a flying saucer-shaped aircraft, which would utilise engine exhaust around three-quarters of the vehicle to provide lift and forward flight. The exhaust system was controlled by a segmented system of flaps, but engineering trials determined that this idea was unsound. It was then suggested that the aircraft might be raised up by about 40° and take off in this position after a short run, using two retractable forward wheels on long struts plus a tailwheel.

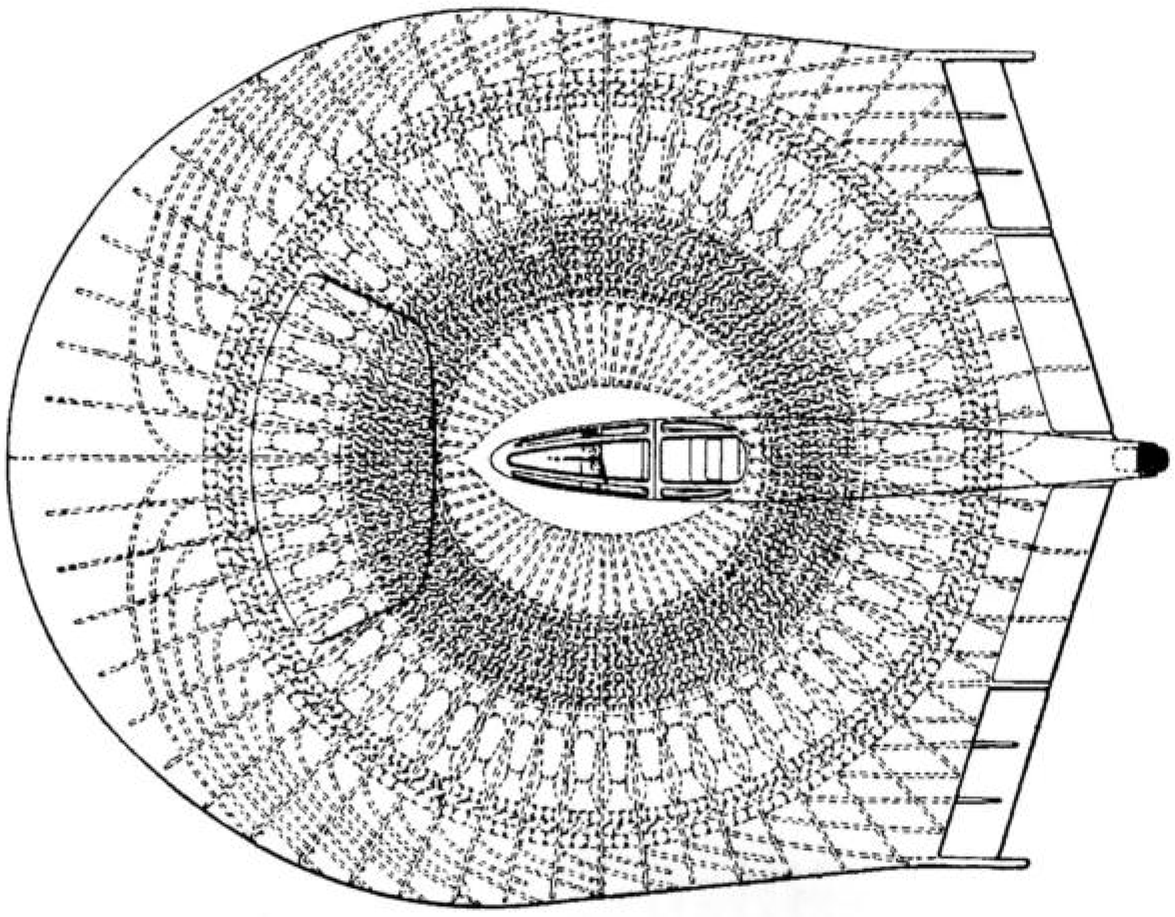
This proposal was also rejected and Frost decided to redesign Project Y as a tail sitter, which took off and landed from a near-vertical inclination. In the tail-sitter configuration, the exhaust flaps were removed and gases were ducted to outlets along each side of the aircraft and through large slots next to the tail. These exhaust vents were subject to a number of design revisions that affected the overall appearance of the aircraft, finally giving it an arrowhead or spade shape.

There have been many claims that Project Y was derived from work carried out by German engineers during World War Two and it has been suggested that Frost participated in debriefing German designers who worked on secret cutting-edge wartime aviation projects. Some evidence of this has come from searches conducted at Canada's National Archives. According to documents recently retrieved by one researcher, an unusual meeting took place at a Canadian Government Facility in West Germany during 1953.

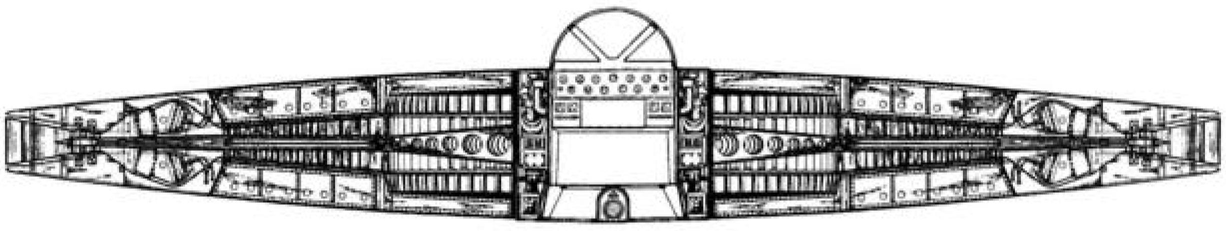


Below: **Early 3-view drawing** (left) **and early sectional drawing** (right) **of Project Y concept.** via Bill Rose and Avro Canada





Right: **A later design proposal for Project Y.** Avro Canada



Below right: **Cross-section of the Project Y aircraft showing the RFGT and cockpit area.** Avro Canada

On this occasion, Intelligence Officers from the RCAF and RAF, accompanied by John Frost, met with an unnamed German engineer who claimed to have worked on a secret flying disc project near Prague, between 1944 and 1945.

Another interesting document regarding the German connection comes from W E Lexow, Chief of the CIA's Applied Science Division and Scientific Intelligence, and is dated 19th October 1955. In this, Lexow says, 'Project Y is being directed by John Frost. Mr Frost is reported to have obtained his original idea for the flying machine from a group of Germans just after World War Two. The Soviets may also have obtained information from this German group'.

Author Bill Zuk mentioned another intriguing event in his book on the history of the Avrocar. He briefly refers to a meeting that took place on 29th January 1958 between members of the SPG and the highly respected German designer Dr Alexander Lippisch, who worked on many advanced wartime aviation projects. There are also indications that the extraordinary engine chosen for Project Y was based on developments carried out in wartime Germany.

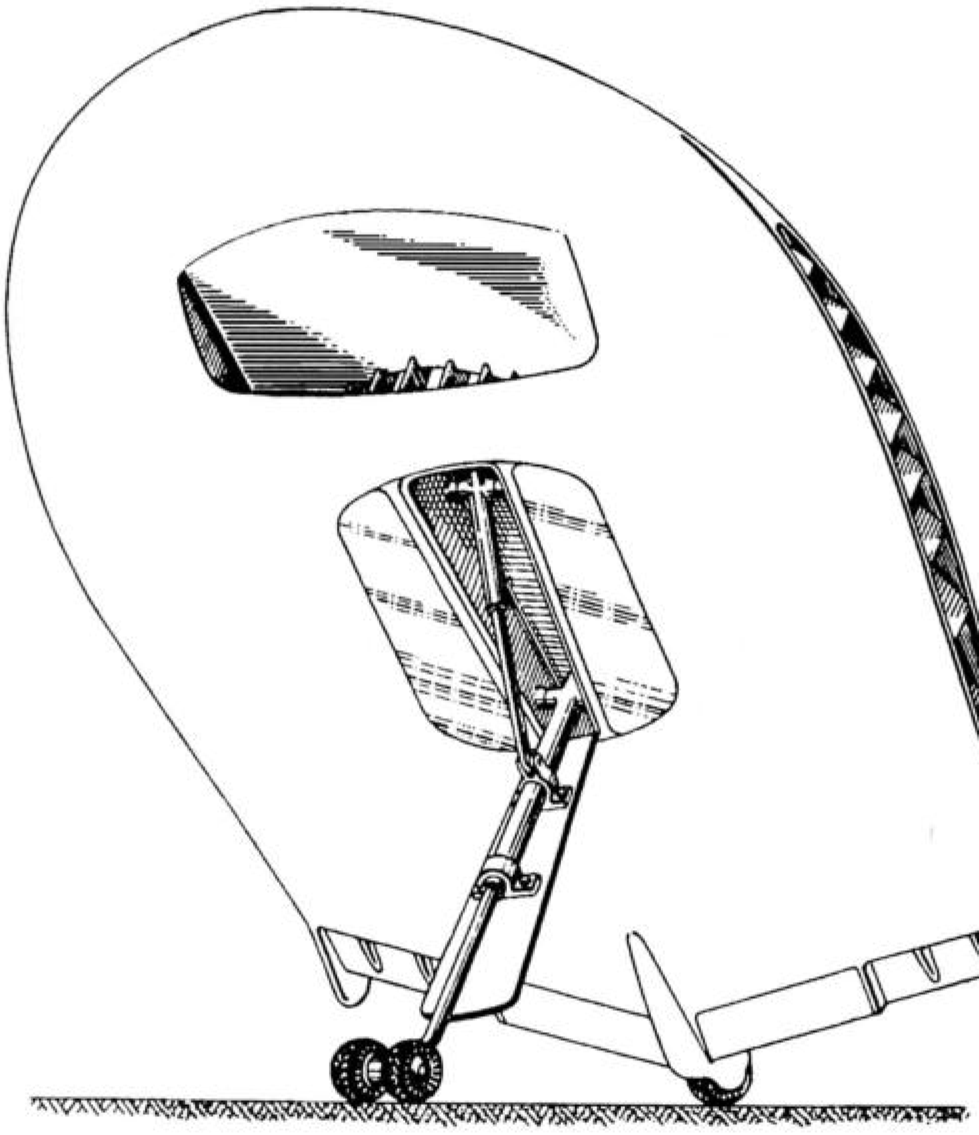
Project Y's propulsion was highly unusual, taking the form of a Radial Flow Gas Turbine (RFGT) which promised to deliver a significantly higher power output than any conventional jet engine of that era. Despite exhaustive enquiries, the exact origins of this design remain unclear and while there have been claims that it was Frost who conceived the RFGT, documents sourced from the Public Record Office (PRO) in Kew, London (now called the National Archives) hint at other possibilities. Based on this material and research conducted in Germany, it seems possible that the RFGT design originated with BMW-Bramo at Berlin-Spandau and that, when the war ended, this technology fell into British hands.

Official UK documents indicate that postwar RFGT development took place at the NGTE (National Gas Turbine Establishment) located at Pyestock, Hampshire, which until 1946 had been Frank Whittle's Power Jets Company. Conceivably, the research project was carried out under the direction of Rolls-Royce's jet engine pioneer Dr Alan Arnold Griffith (1893-1963). This brilliant scientist independently developed the gas turbine engine and proposed a contra-rotating turbofan, some decades before it became a practical proposition. He favoured the complex axial flow compressor system in preference to Frank Whittle's simpler centrifugal design (before either engine had been built) and remained at the forefront of advanced gas turbine research throughout his career.

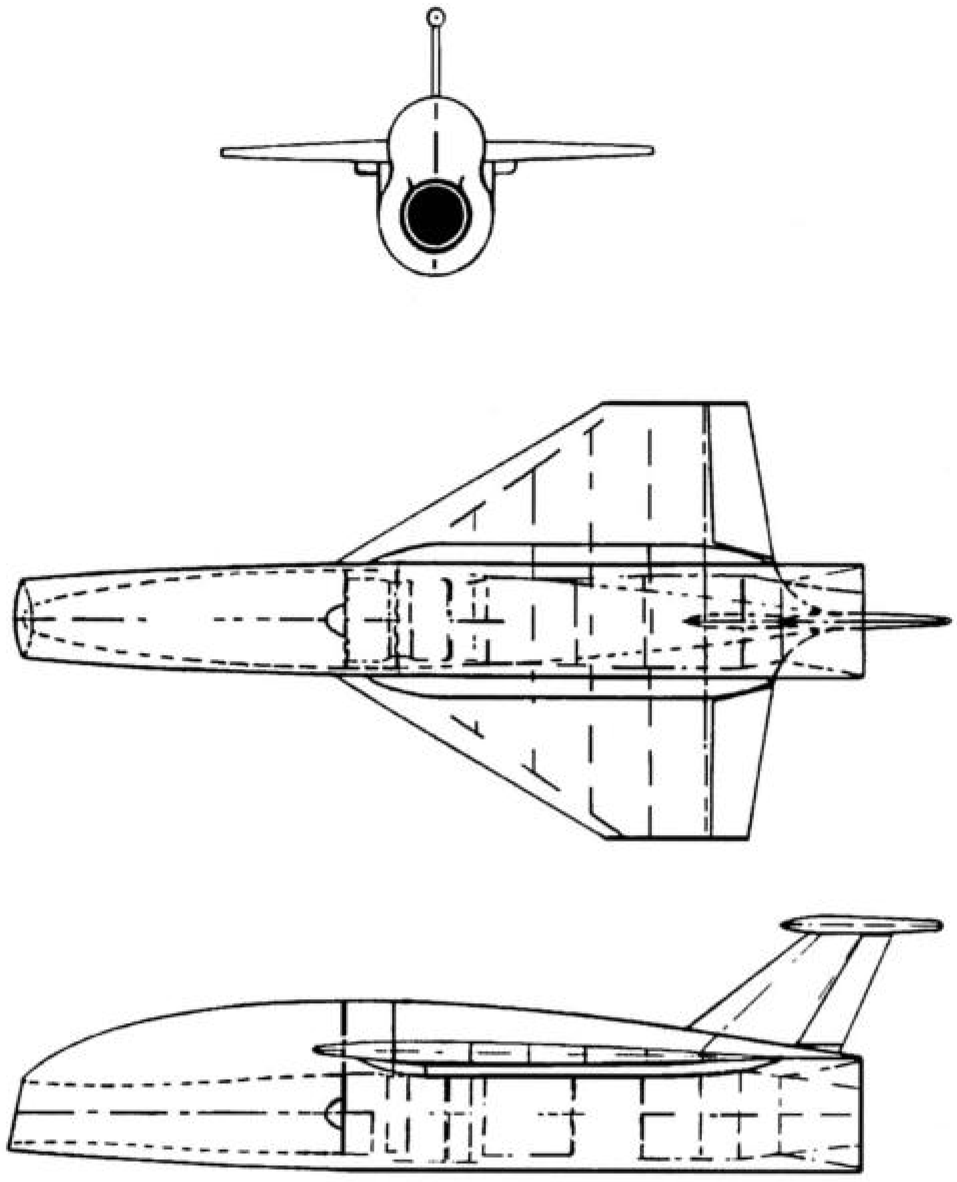
While Project Y was under development, Griffith became particularly interested in VTOL concepts and is now best remembered as the designer of Rolls-Royce's experimental Flying Bedstead, which 'flew' in 1954. John Frost was a friend of Frank Whittle and Alan Griffith, and some unconfirmed reports suggest that Griffith assisted the SPG team in Canada.

The RFGT can crudely be described as a jet engine stood on its tail and then flattened out into a disc, working 'edge on' to the direction of flight. Because there is a large compressor and turbine that revolve around the centre of the aircraft, the RFGT provides gyroscopic stability and theoretically makes the vehicle a very steady weapons platform. Air for the RFGT engine is drawn in through two forward-facing intakes on the upper and lower surfaces of the fuselage, is compressed, and is then forced into the surrounding combustion chambers. Exhaust gas then flows through the radial turbine (which is driving the compressor) to the outlets.

Technical information for the first Project Y powerplant shows that the rotating assembly was reliant on roller bearings, although they were soon replaced with a more satisfactory air bearing system. On a less positive note, the engine formed an integral part of the Project Y airframe, so a major service or the replacement of certain components would have involved considerable labour. Furthermore, the integration of this engine with the airframe would seriously limit scope for future upgrades and improvements.



A drawing of the proposed Project Y aircraft, showing the use of a single landing leg and glass panels below the cockpit. Avro Canada



Avro UK P.724 VTOL interceptor Mk 1 design. via Bill Rose

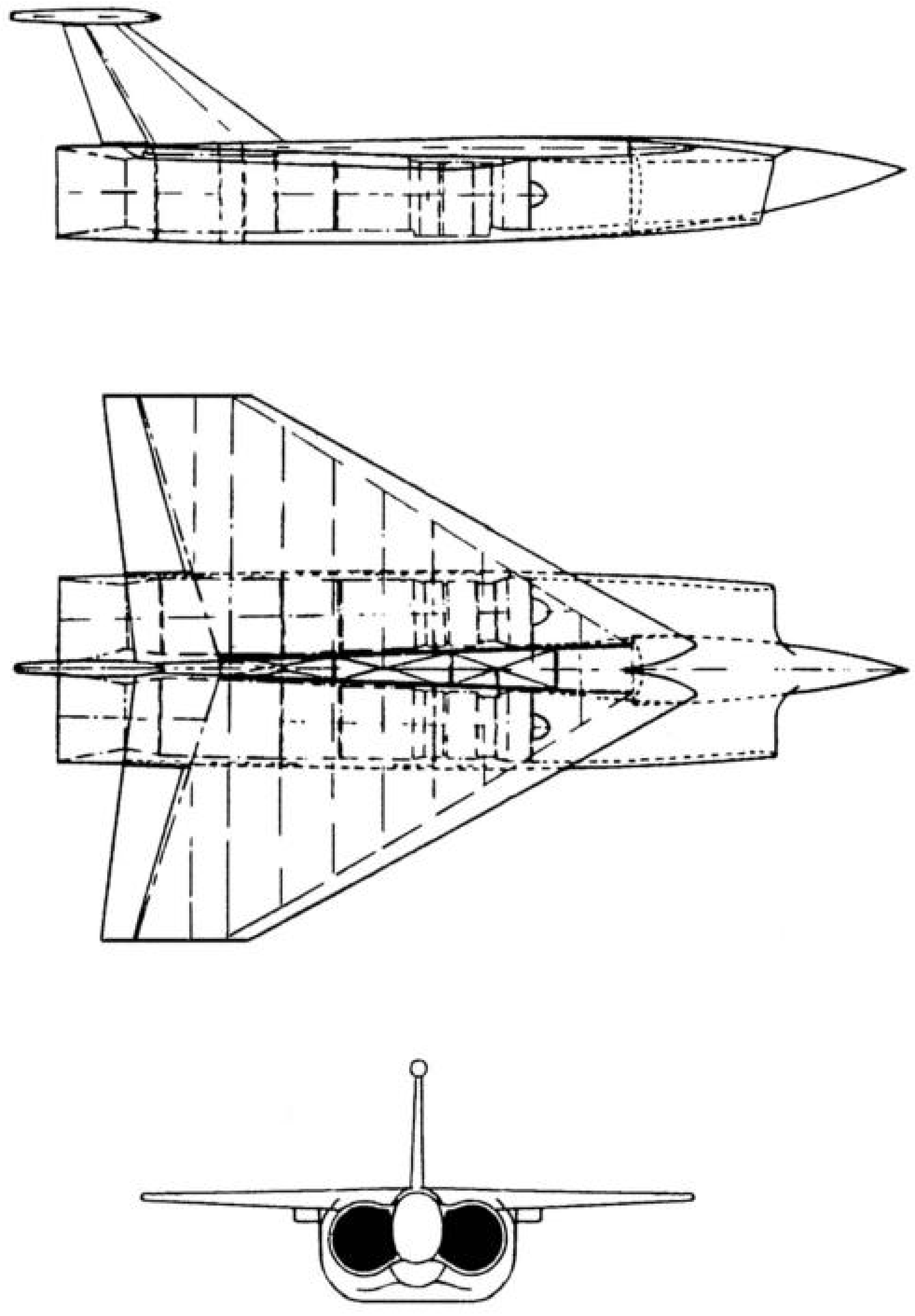
The Project Y interceptor was expected to attain a maximum speed of about Mach 2.25 in level flight, with a service ceiling of 65,000ft (19,812m). Estimates of range are less clear, but 1,000 miles (1,609km) was considered realistic. Armament proposals included two or four cannons and/or spin-stabilised FFARs (Folding Fin Aircraft Rockets). It was also thought that British de Havilland Blue Jay air-to-air missiles might be fitted at some point in the future. No provision was made for an intercept radar and it's hard to see how bulky electronic equipment of that era could have been accommodated in such a design. At that time airborne radar required a second crewmember and the RCAF may have believed that the CF-100 would fulfil the night/all-weather role, while Project Y would operate as a high-performance daylight interceptor directed from the ground.

A good deal of Project Y's initial development was undertaken by Avro at Manchester, England: this included engine integration studies and wind tunnel testing. According to a previously secret USAF document from 1959, which outlines the background to the Avrocar, a small, unmanned Project Y demonstrator was test flown by Avro UK in 1953, although records of these trials (and many other important historical documents) were lost in a serious fire that took place in 1959. During a meeting in Britain during March 1953, which was attended by Dr Ormond Solandt and Sir Roy Dobson, it was agreed that Project Y showed considerable promise. Dobson made it clear that Avro UK and the RAE were still interested in Project Y, but they were waiting to see further studies of a similarly specified Avro (UK) proposal called P.724.

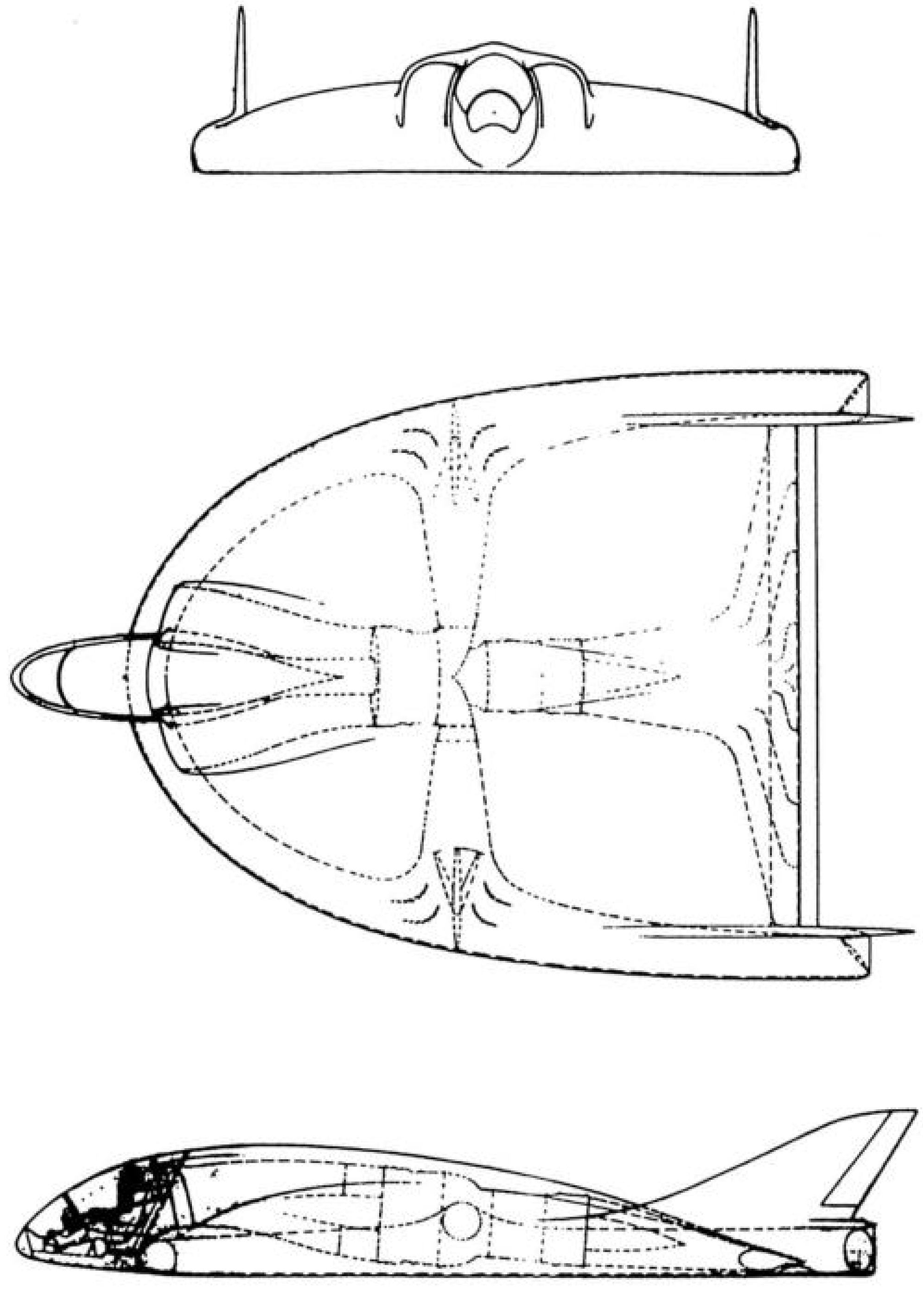
The initial P.724 proposal had been for a VTOL tail-sitter powered by the newly designed high-performance Rolls-Royce RB.106 axial flow turbojet engine, which had a quoted static thrust of 15,000 lb (66kN), rising to 21,800 lb (97kN) with reheat. This was a technically advanced design, using two separate axial flow compressors driven separately by single-stage turbines. Reheat was an integral feature of the RB.106 engine with an automatically controlled convergent-divergent propelling nozzle. Although the RB.106 was finally cancelled in 1957 as a consequence of the UK's ill-considered stance on fighter development, much of the technology found its way into the Orenda Iroquois turbine developed for the Avro Canada CF-105 Arrow.

P.724 was a semi-dart-shaped aircraft with a nose air intake. It had an overall length of 32ft 6in (9.91m) and a wingspan of 16ft (4.88m). In its upright launch and landing position the P.724 would have been supported by a shock absorbing leg carried in the single tailfin and two other legs that retracted into fairings along the wing roots. The flush cockpit occupied a forward section of the lower fuselage and the pilot would fly the aircraft in a prone position. However the Avro designers soon realised that it would be difficult if not impossible to achieve a satisfactory thrust/weight ratio with a single engine and they therefore progressed to a twin-engined configuration.

The twin-engined P.724 used two RB.106 engines, which led to a new airframe with a 60° delta wing that looked somewhat like a half-sized Avro Canada Arrow. The overall length of the twin-engined P.724 was 37ft (11.28m) and the wingspan was 24ft (7.32m). Weight fully laden was expected to be 24,500 lb (11,113kg), which included 8,000 lb (3,628kg) of fuel carried in the wings and central tanks. Estimates suggest that the P.724 would have been capable of Mach 2.5, with a service ceiling of at least 60,000ft (18,288m). Both afterburning RB.106 engines would have been supplied with air from forward intakes alongside the nose, which housed the pressurised cockpit and accommodated the pilot in a prone position. This version of P.724



Avro UK P.724 VTOL interceptor Mk 2 design. via Bill Rose



Hawker Siddeley VTOL fighter concept. Based on an image provided by Joe Cherrie, enhancement by Bill Rose

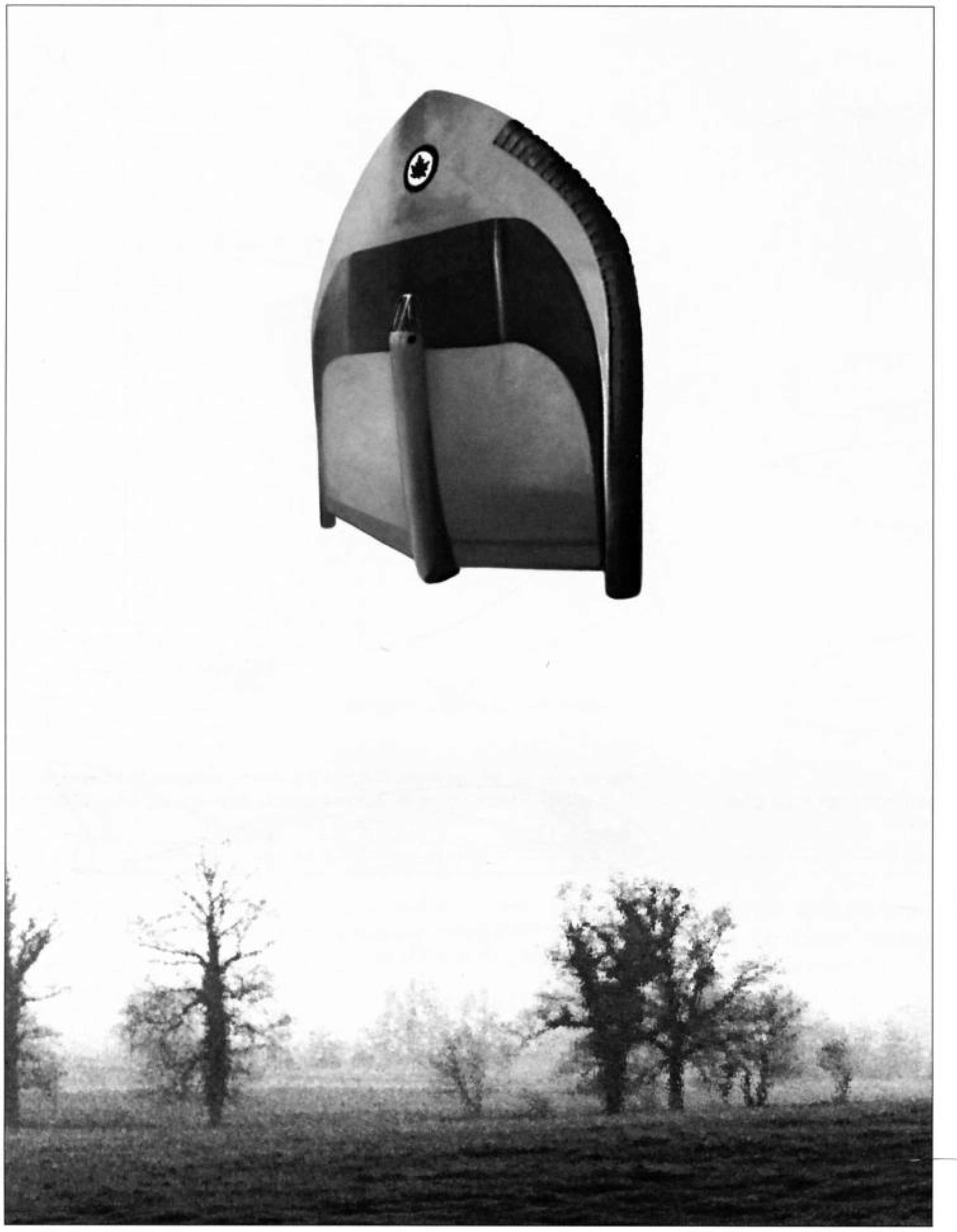
was supported in an upright position on the ground in exactly the same manner as the single-engined version, using a retractable shock absorbing leg fitted in the tail fin's pod and two retractable legs that were housed in underwing fairings during flight. Airborne radar was planned for this aircraft and armament would have comprised two Blue Jay (later renamed Firestreak) air-to-air missiles, mounted on wingtip launch rails.

Three months after the discussion between Dr Ormond Solandt and Sir Roy Dobson, several P.724 models had been tested in Avro UK's wind tunnel. In turn this indirectly led to a meeting between John Frost, who was trying hard to sell his Project Y aircraft to the RAF, and Sir William Farren of the RAE. They finally agreed that the Avro P.724 would probably have similar performance to any aircraft of the same size and weight that was powered by an RFGT. However, Farren accepted that the combination of a radial flow engine with a circular wing or delta shape would lead to some very real aerodynamic advantages that included improved stall characteristics.

Nothing really conclusive came from this meeting and, while the Canadian effort to promote Project Y continued, the RAF had shifted its interest to the mixed-propulsion interceptor to meet the OR.301 specification. On the other hand, Avro UK were still exploring the idea of using a radial-flow gas turbine engine in a triangular-shaped aircraft and this small-scale study lasted for the next two or three years. At the same time Avro UK examined alternative proposals for a VTOL flat-riser fighter produced by A A Griffith at Rolls-Royce.

One of his concepts was for a two-seat VTOL interceptor with Mach 2.8 performance that used at least ten RB.108 turbojets for lift. This was followed in 1957 by a heel-shaped VTOL fighter design produced at Hawker Siddeley, Kingston, which may have been intended to compete directly with the later Avro Canada WS-606A. Thought to have been designed by John W Fozard, this flat-riser ducted the exhaust flow from its centrally located Bristol BE.53 turbojet to a peripheral plenum chamber that dispersed gases below the aircraft, generating lift for take-off and landing. A rear letterbox exhaust vent provided stability with a flap to divert some exhaust downwards. Once airborne, internal doors would be used to divert all exhaust gas to the rear of the aircraft for level flight, with small doors in the two outer exhaust ducts for additional yaw control. No project reference was assigned to this very innovative Hawker-Siddeley concept, probably indicating that it never progressed very far beyond the drawing board.

As work on Project Y progressed in Canada, the design team ran into serious engineering problems caused by the steep take-off and landing angle which was now set at about 75°. To support the aircraft a single, very long, retractable undercarriage leg was fitted, which worked in combination with a small tailwheel. This arrangement led to the aircraft being called Manta or Praying Mantis by the design team. The name Jump Gyro can also be found in some company documentation, but the official company name of this aircraft became Ace. Two glass panels were proposed for the cockpit floor to provide the



Simulation of Project Y aircraft in hover mode during untethered test flight. Bill Rose

downward visibility that would have been essential during landing. However, it was obvious to everyone that the undercarriage arrangement was far from satisfactory and a series of alterations were subsequently made to the layout.

In its revised form, the aircraft was raised fully upright to a 90° position. Support was provided by a retractable wheel on a long strut that was housed in the dorsal spine, while two retractable legs extended from the underside. This formed a tripod configuration, but it proved no better than the previous design and, as a result, the entire project was abandoned. However, Project Y had provided valuable data on RFGT engine integration and Avro's engineers realised that the initial idea of building a completely circular aircraft would be much simpler in terms of component fabrication and assembly.

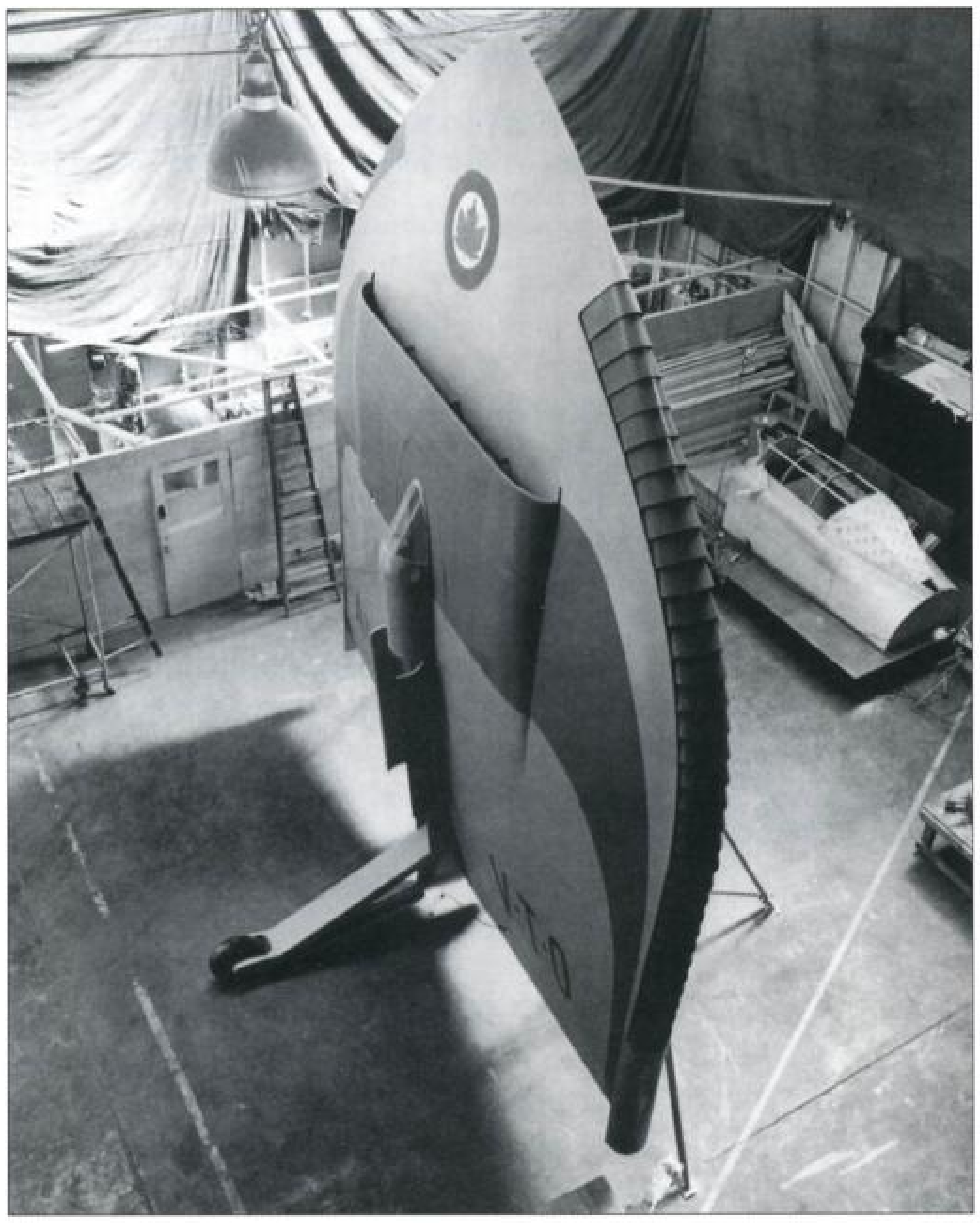
When Frost abandoned the Ace and suggested a new approach, the CDRB simply decided to scrap the entire project. They were already preoccupied with finding a suitable aircraft to fulfil the new RCAF Specification 7-3, which eventually led to the superb but ultimately ill-fated Avro Canada CF-105 Arrow supersonic interceptor. So at this point in time the USAF, represented by Lt General Donald Putt, came forward with $200,000 to continue with Frost's work and a promise to maintain adequate financial support for the programme. (Interestingly, Putt was heavily involved in analysing and back-engineering exotic German wartime aeronautical projects at Wright-Patterson AFB.)

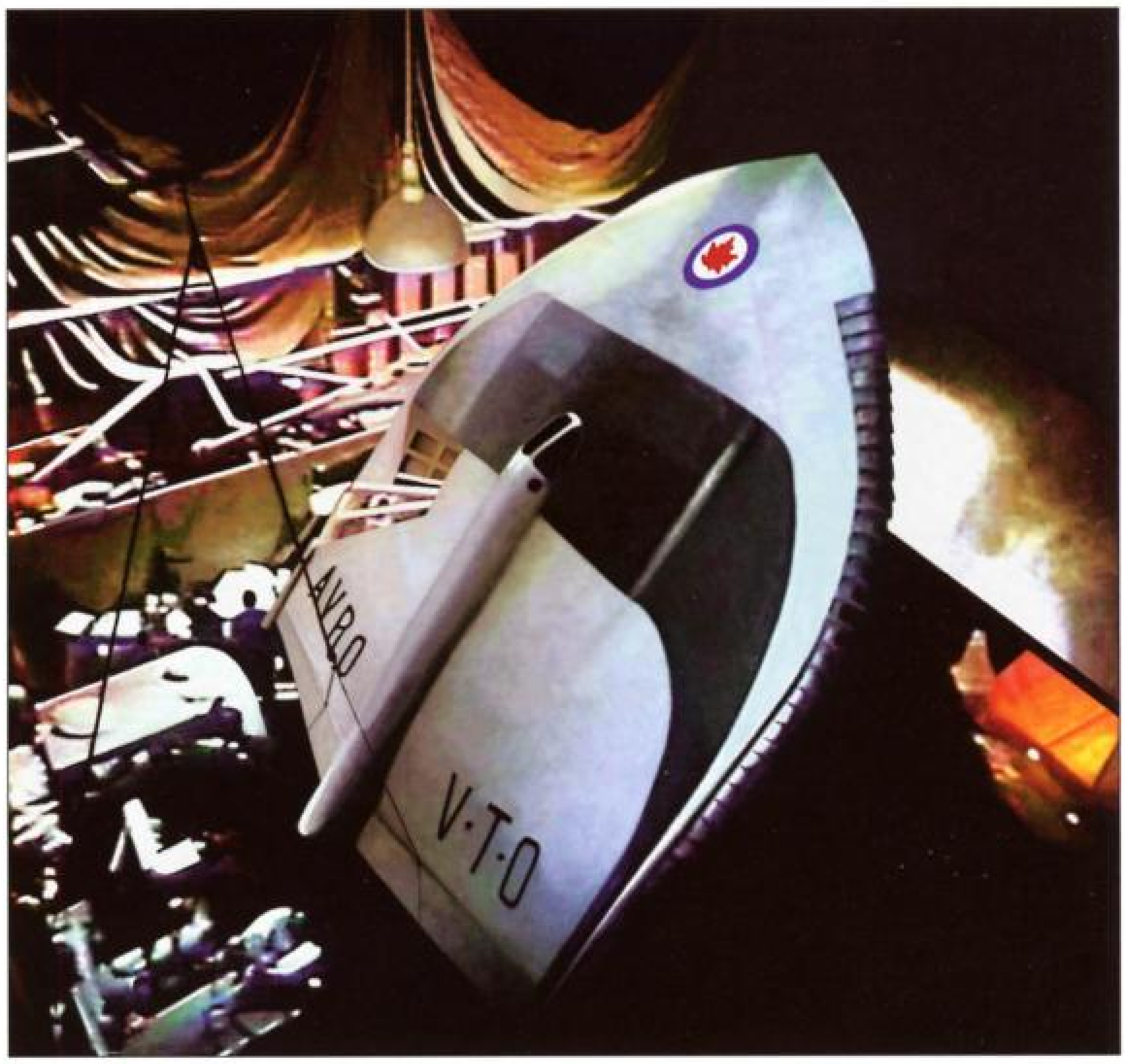
Evidently, the British were not unhappy with this American move because they had already considered the possibility of taking over Project Y but had finally decided that government R&D money could be better used elsewhere. Satisfied that Avro Canada could retain all its rights and that technical information would be made available to the RAE and Ministry of Supply, the US adoption of Project Y received HMG's official blessing on the recommendation of Sir Roy Dobson and Sir William Farren. Now the Americans were directly controlling Avro Canada's SPG, the USAF opened a new project office at the Air Development Center within Wright-Patterson AFB, Ohio. The USAF could see great potential in Frost's work, so a number of US scientists were assigned to the programme and several impressive research facilities were made available to his team.

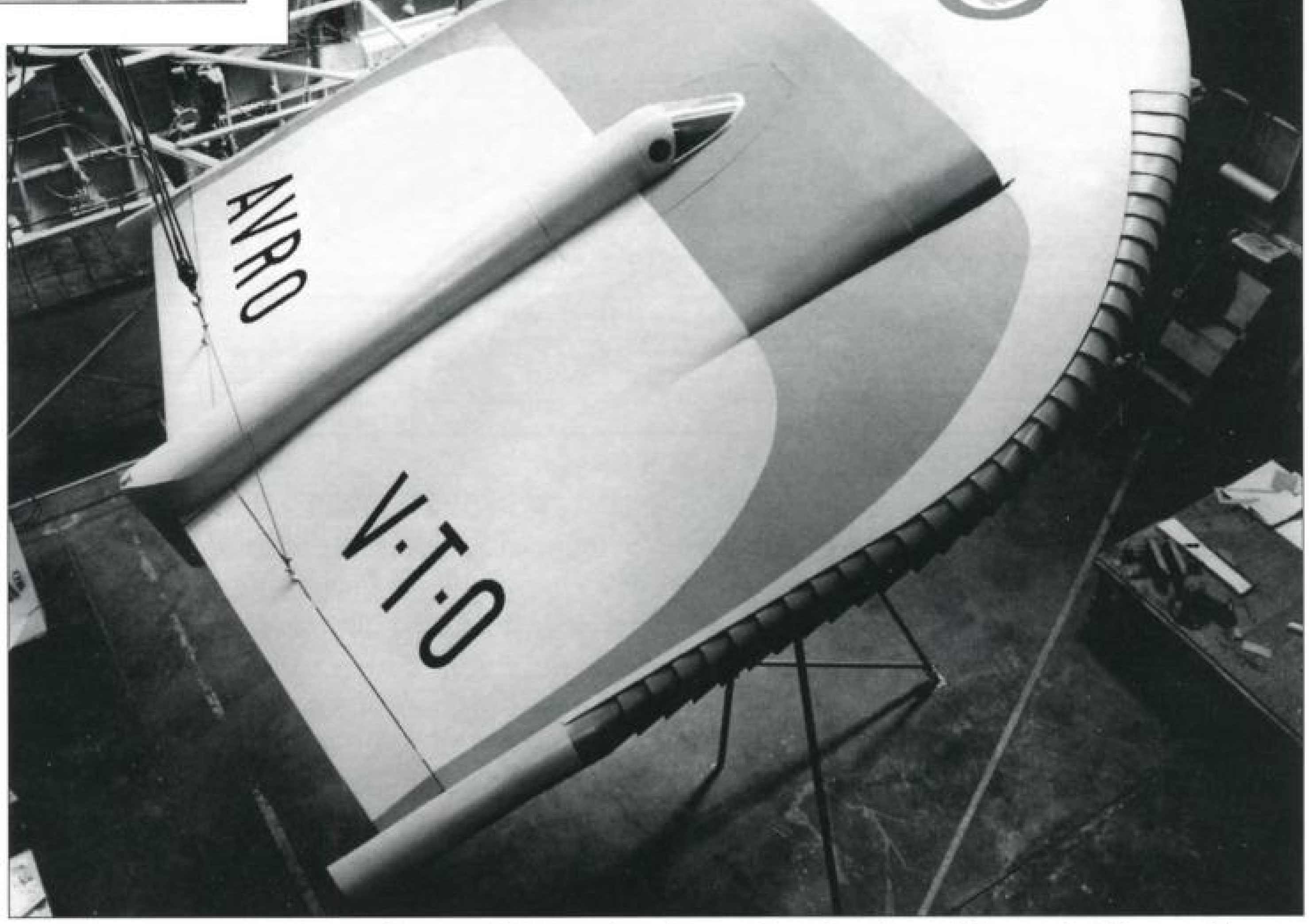
From the very beginning of Project Y, Canadian newspapers carried unconfirmed reports that Avro were developing a revolutionary type of flying saucer for the RCAF. In February 1953 *The Toronto Star* published a reasonably accurate description of the Project Y design, which soon found its way into an *RAF Flying Review* article entitled 'Man-Made Flying Saucer'. From this point onwards, media interest in Canada's flying saucer project intensified and during April 1953 *The Toronto Star* (who seemed to have useful contacts within Avro) announced that Britain's Field Marshal Montgomery had become the first visiting VIP to be shown a full sized mock-up of the company's VTOL combat saucer.

The mock-up was undoubtedly the Project Y tail sitter shown in recently discovered photographs. Evidence now suggests that this was much more than a simple mock-up and it was used for full engine integration trials. British Minister Duncan Sandys also visited Malton in 1953 and he was shown the Project Y mock-up. Former Avro Canada employees interviewed during 1999 and 2000 have all insisted that tight security measures were in place, but details of the flying disc project still trickled out of the company. Newspapers continued to refer to the aircraft as Project Omega, which they correctly reported to be powered by a unique ring-shaped gas turbine.

In the late 1980s a woman with the initials L P, who was living in Switzerland, claimed to have seen an unusual disc-shaped aircraft at Avro's Malton plant. Apparently, L P worked







Above: **The Project Y mock-up at Malton.** via Bill Rose

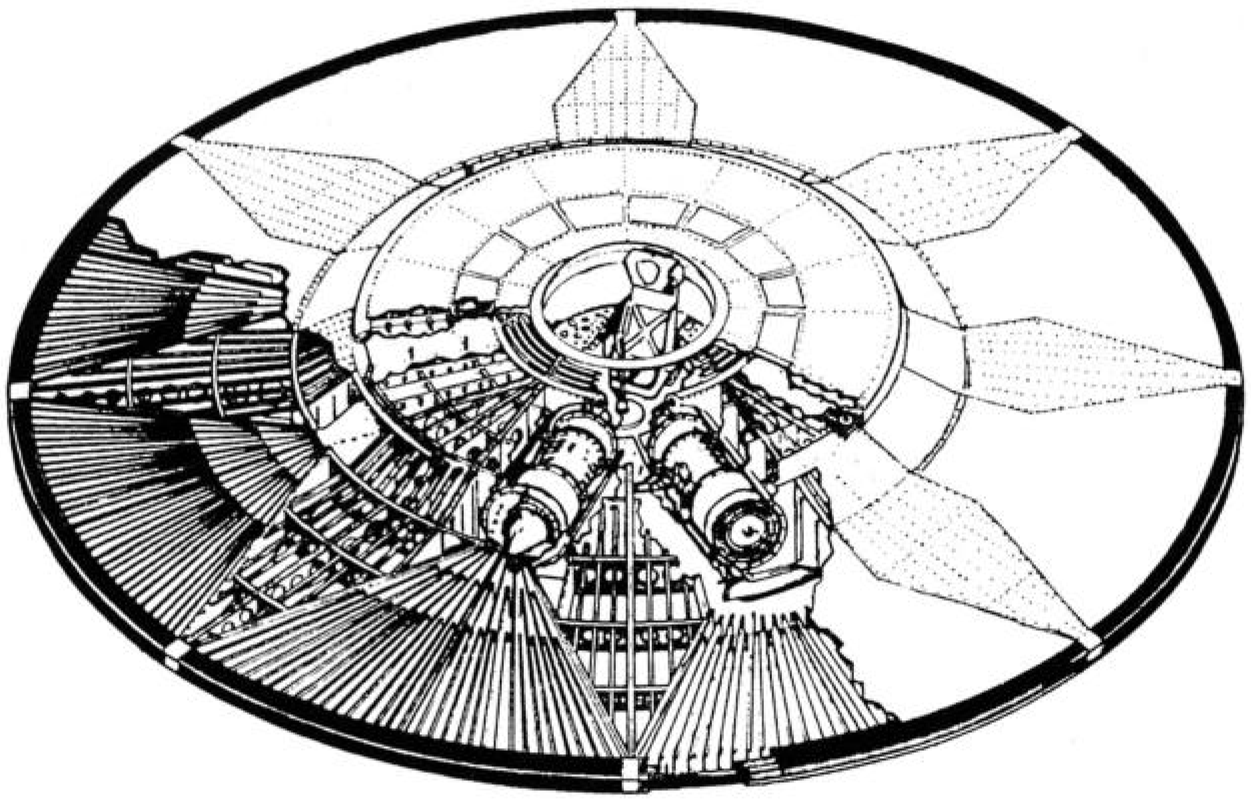
Above right: **This is the only known colour photograph of the Project Y mock-up at Avro Canada's Malton facility.** via Bill Rose

Right: **Inside the Special Projects Group building at Malton, Avro Canada's Project Y mock-up is seen during engineering development trials.** via Bill Rose

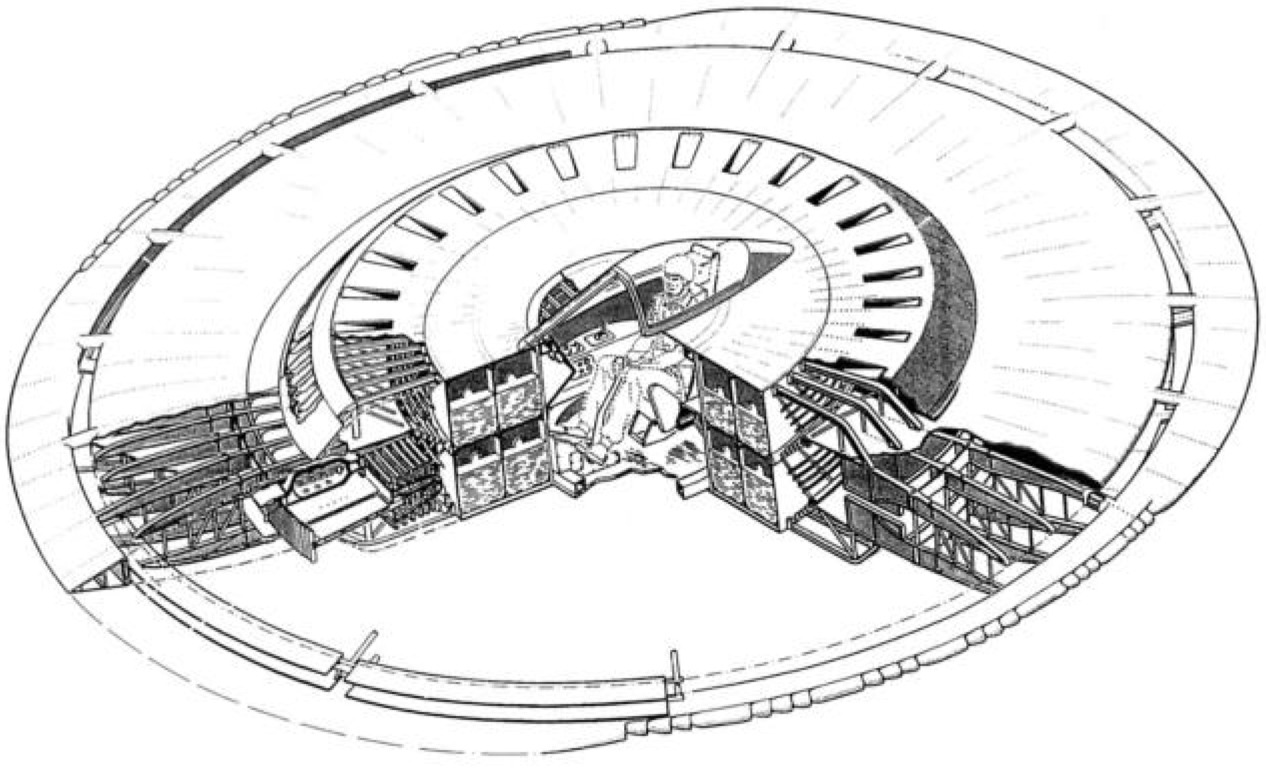
in the cafeteria during the 1950s and late one night, while taking a different route home, she accidentally caught a glimpse of a flying saucer in an open hangar. The aircraft was about 30ft (9.1m) in diameter and L P was surprised to see an armed American guard by the hangar door. Unfortunately, the exact date of this incident remains unknown, but the witness thought it was about 1954. Whether this was the mock-up of Project Y shown to Field Marshal Montgomery or (as seems more likely) the mock-up or prototype of a more advanced Y2 design remains unknown, but the story appears to be quite genuine.

That same year, Avro Canada's saucer became a hot domestic issue and the Canadian Government unexpectedly admitted that a disc-shaped combat aircraft had been under development at Avro Canada, but all work had now ceased due to spiralling costs. It seemed that $100 million was needed to complete the programme (several billion in today's money!). Some American correspondents believed that Avro Canada was still developing a long-range disc-shaped interceptor, primarily funded by the Pentagon, and they continued to suggest this in print.

Then, on 13th June 1955, the USAF issued a brief press release that acknowledged the existence of a contract (Ref: AF33 (600) 30161) with Avro Canada. USAF Secretary Donald Quarles followed this with an announcement that negotiations were under way to start full-scale production of a revolutionary disc-shaped combat aircraft designed by John Frost. The US and Canadian press gave full coverage to the Avro flying saucer story, while the USAF subtly suggested that some aspects of the arrangement had been intentionally leaked to the media in an attempt to discredit Canada's Defence Pro-



Design for the small Project Silver Bug eight-engined research craft. USAF



Sectional view of the more advanced Project Y2 Silver Bug aircraft powered by a radial flow gas turbine. USAF

duction Minister C D Howe. Perhaps not surprisingly, Howe was blamed for withdrawal of support for the flying disc programme, which allowed the Americans to take it over!

The Bugs

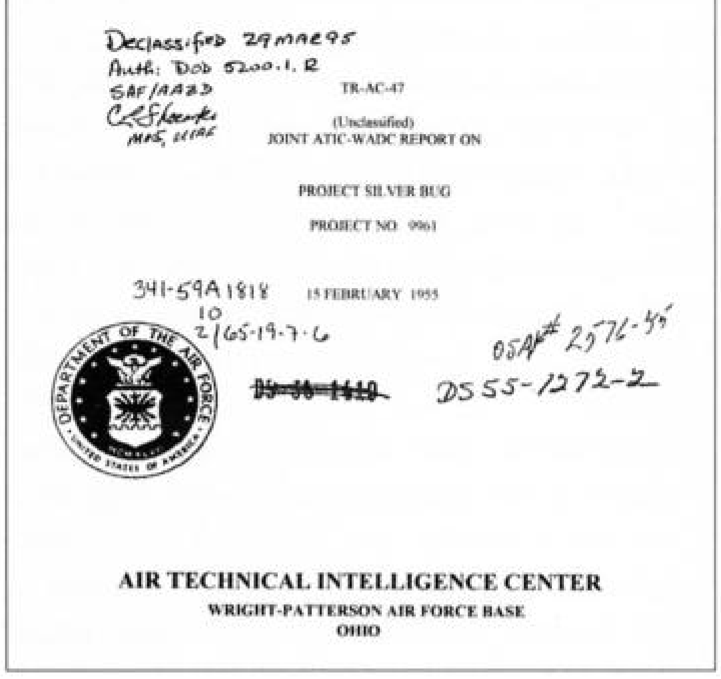
By July 1954 several successors to Avro Canada's Ace were on the drawing boards, when the Pentagon effectively took control of Avro Canada's SPG. The American commitment also meant that USAF scientists working at Wright-Patterson AFB became directly involved with the work, along with some of the best aeronautical specialists at The Massachusetts Institute of Technology (MIT) and NACA Ames in California.

In 1995, previously secret USAF documents concerning Avro Canada were declassified under the US Freedom of Information Act (FOIA). They showed that John Frost's group were developing two different aircraft designs in 1954, under a USAF programme known as Project 9961 Silver Bug, which was another name for Project Y2. Both Silver Bug aircraft stemmed directly from research carried out during Project Y and the first design took the form of a small circular one-man subsonic VTOL research aircraft with a diameter of 21ft 6in (6.55m).

This design was powered by eight Armstrong Siddeley Viper axial flow turbojet engines that drew air through inlets around the centre of the aircraft and ducted exhaust to the edge of the disc. When hovering the lower air inlets would be closed and the exhaust gases would be directed downwards to create a powerful ground cushion effect, which was similar to the system proposed for the first Project Y aircraft. The cockpit was located at the centre of the flying disc and covered by a one-piece dome-shaped transparency. An ejector seat was fitted and space for the pilot can only be described as rather limited, with a serious restriction on downward visibility. Any centrally mounted cockpit in a disc-shaped aircraft would suffer from this problem and in an attempt to improve matters a glass panel was set in the floor below the pilot's legs.

The more advanced aircraft powered by a RFGT engine seems to have been designed from the outset with a military role in mind and it was initially given the secret USAF codename Project Ladybird. Rather puzzlingly, schematics of this 29ft (8.84m)-diameter flying disc show little spare internal space that might be used for weapons carriage. Like the smaller research vehicle, no type of undercarriage was proposed, although it seems probable that retractable landing legs would have been fitted to facilitate easy ground handling and avoid damage to the underside of the aircraft.

The performance of this aircraft would have been nothing short of astonishing, with an estimated maximum speed of Mach 3.5 and a service ceiling in excess of 80,000ft (24,384m). USAF figures indicate that this design was expected to be capable of reaching 70,000ft (21,336m) in 4.2 minutes from a hovering position. Because of the aircraft's 950 Imperial gallon (4,318 litres) fuel capacity and gross weight of 29,000 lb (13,154kg), its range was limited to about 620 miles (997km). However, the question of thermal build-up at sustained supersonic speeds



TECHNICAL REPORT

Declassified 29MAR95
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(Unclassified)
JOINT ATIC-WADC REPORT ON

PROJECT SILVER BUG

PROJECT NO 9961

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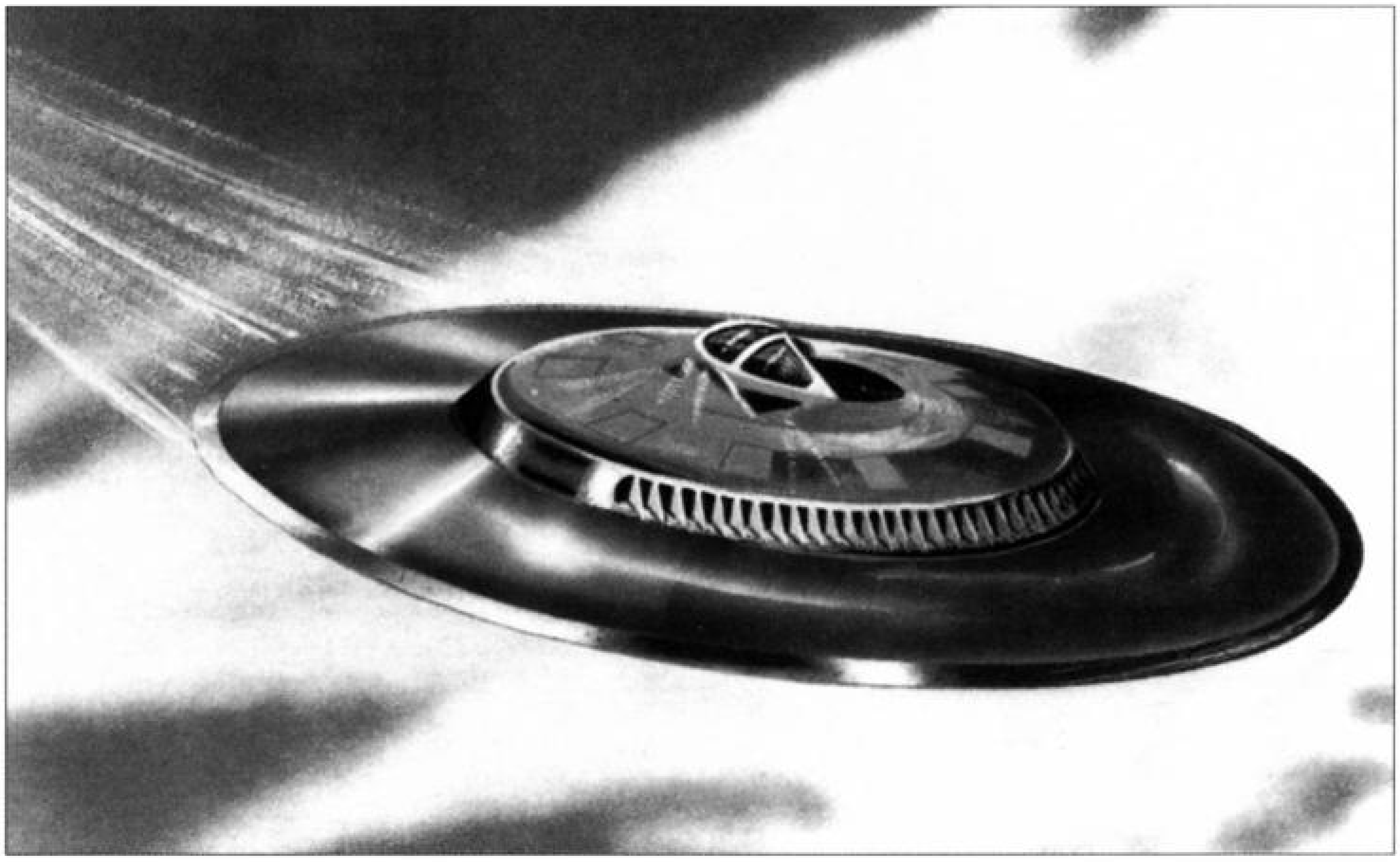
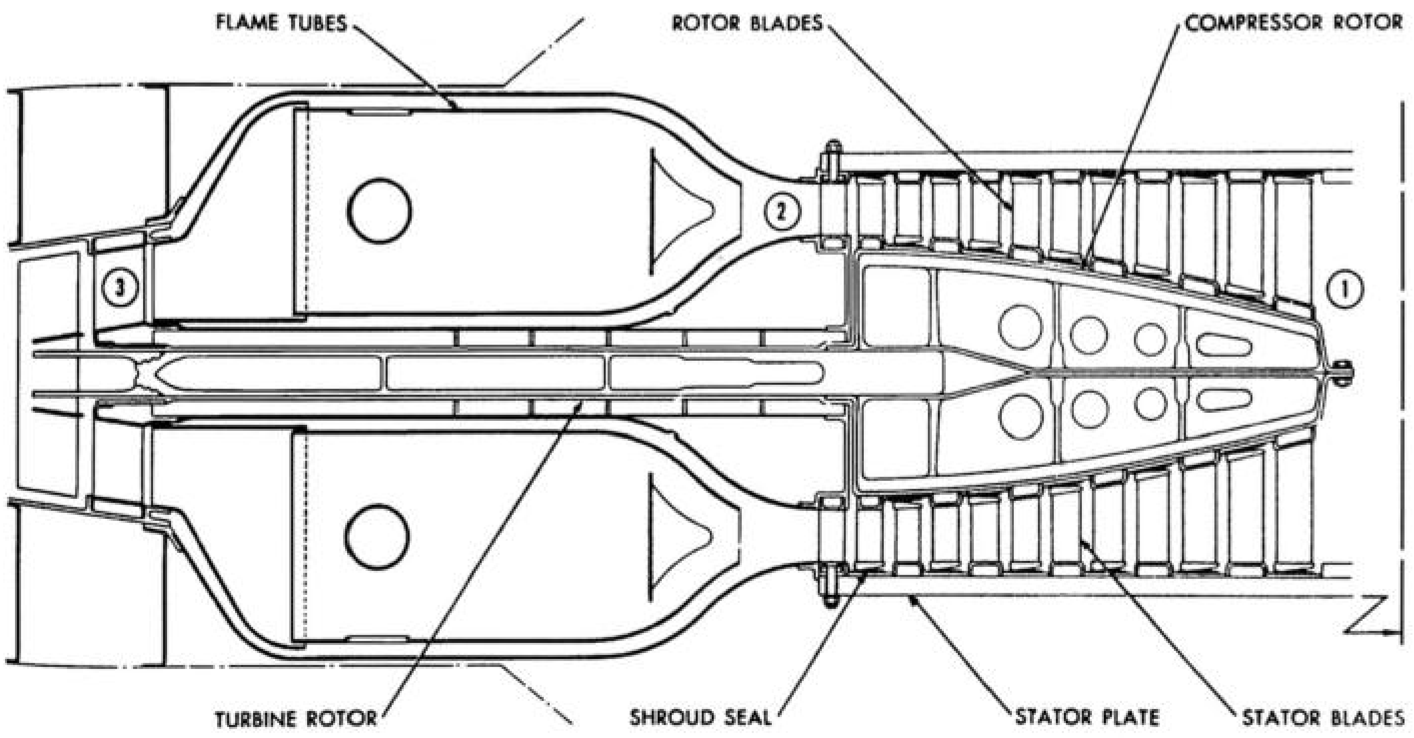
AIR TECHNICAL INTELLIGENCE CENTER
WRIGHT-PATTERSON AIR FORCE BASE
OHIO

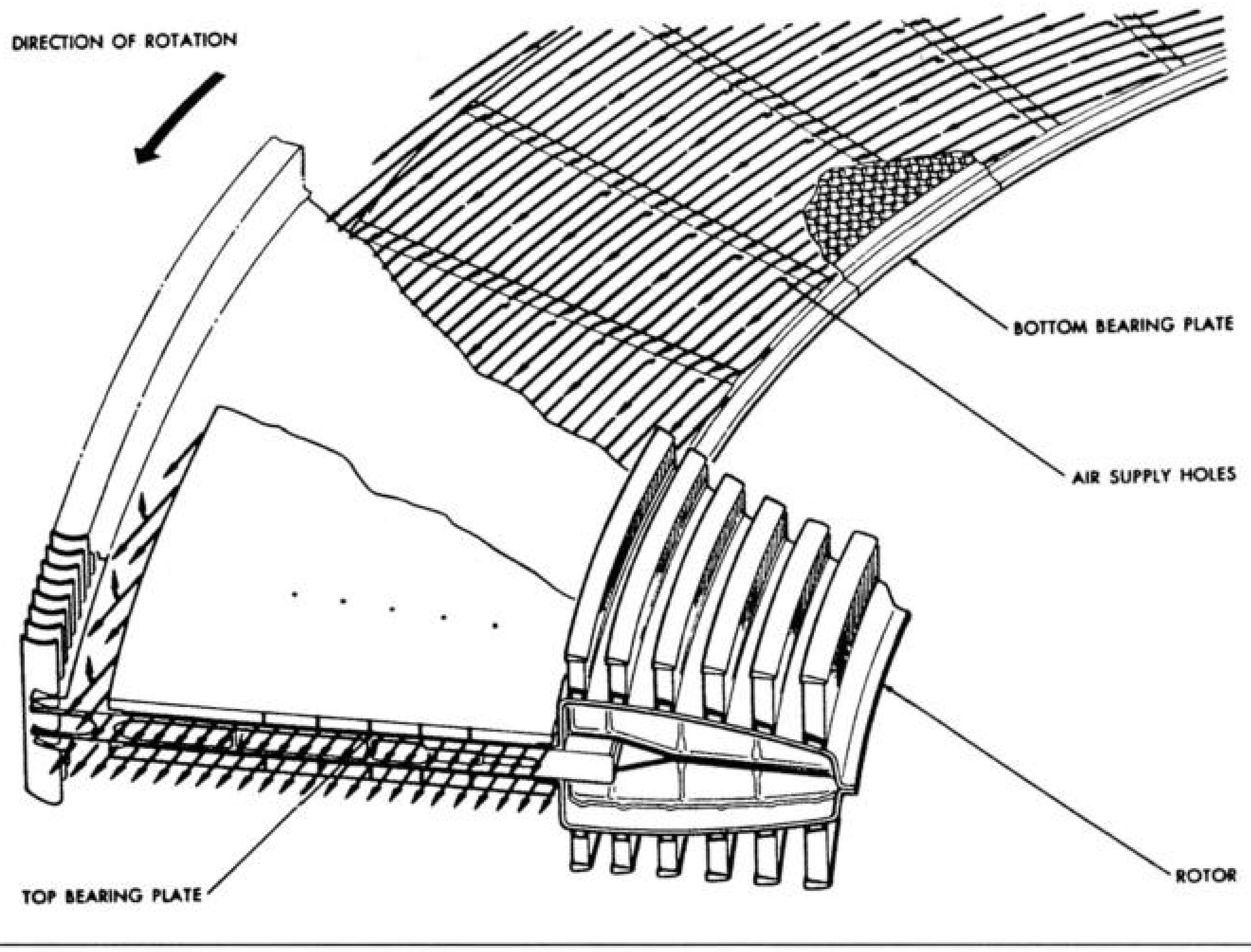
USAF Project Silver Bug document cover. USAF



Project Y2 Silver Bug aircraft concept illustration. USAF



A cross-section of the radial flow gas turbine engine used in Project Y2 aircraft. USAF



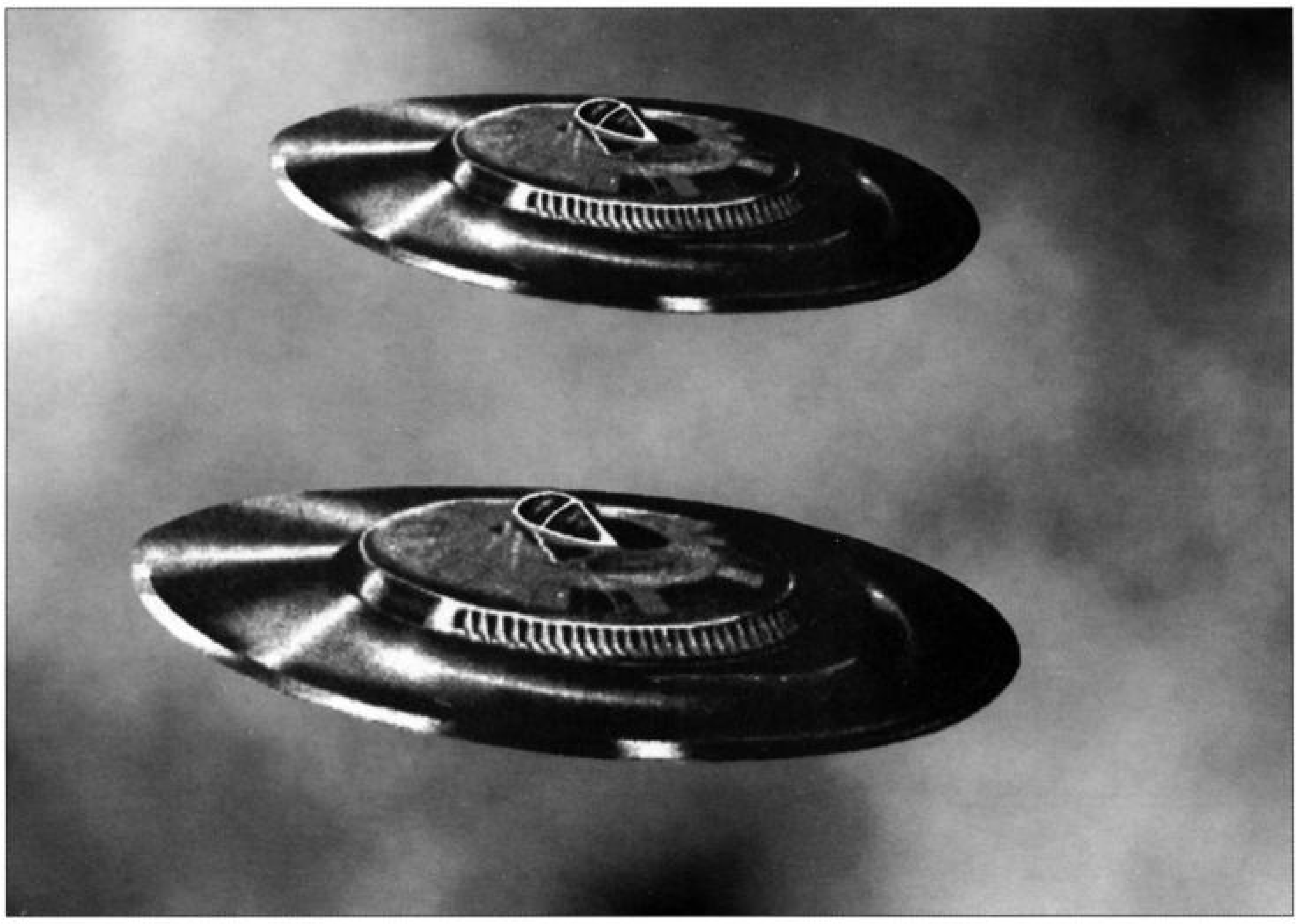
Project Y2 Silver Bug cross-section of bearing design. USAF

could not be entirely dismissed. In 1955 the best readily available metals were less than ideal for airframes and skins that might be subjected to very high temperatures. To counter this the USAF hoped to partly overcome the problem by dumping excess heat into the central fuel tanks.

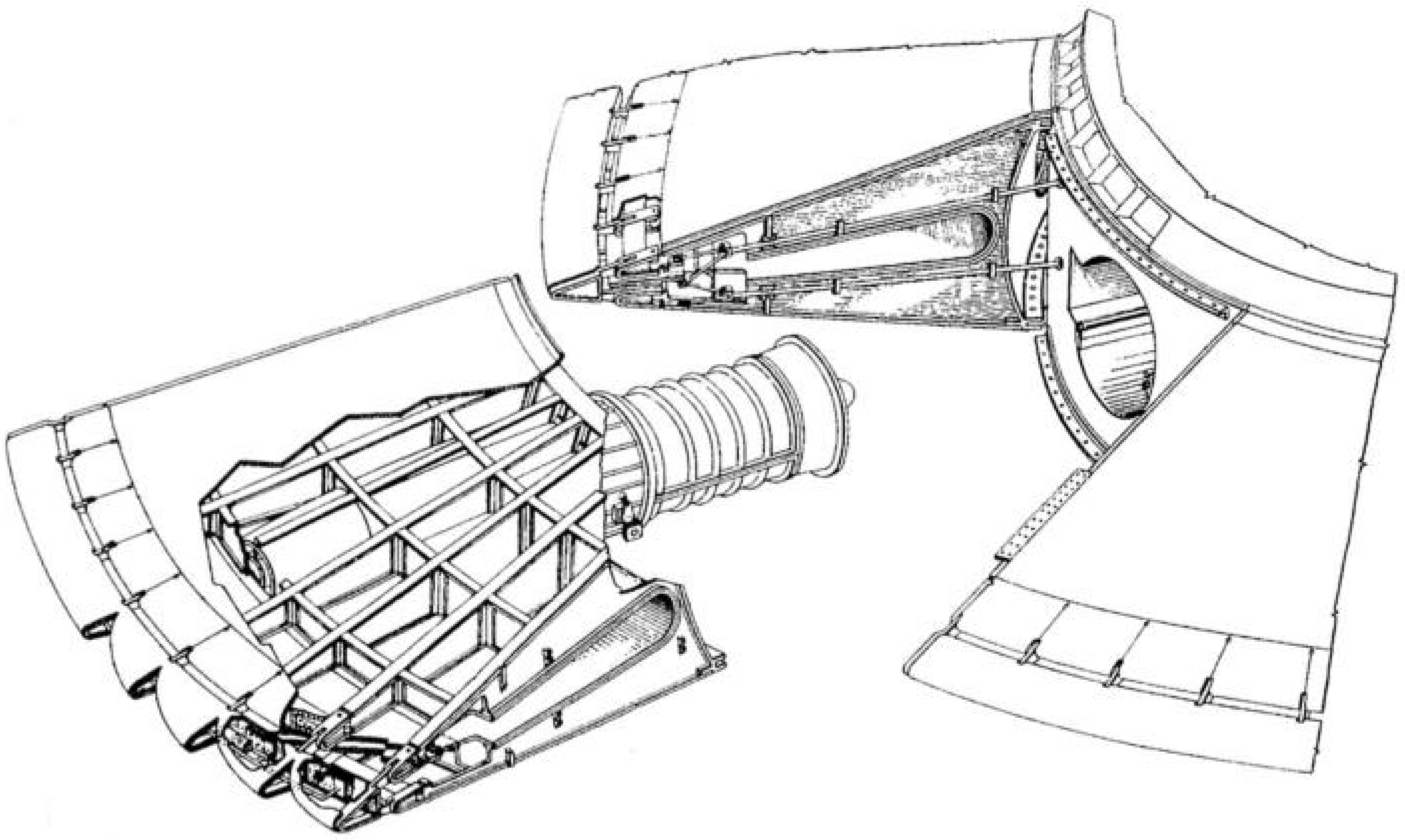
The powerplant proposed for this aircraft was a very sophisticated RFGT. Under development by Orenda Engines (Avro Canada's jet engine division), it was based on the earlier design for Project Y. This second-generation RFGT drew air through upper central inlets for VTOL operation and front-facing upper and lower inlets for forward flight. An air bearing was used to support the compressor/turbine wheel and the combustion chambers were coupled to a reheat system, which ducted gas to a fairly complicated arrangement of exhaust vents.

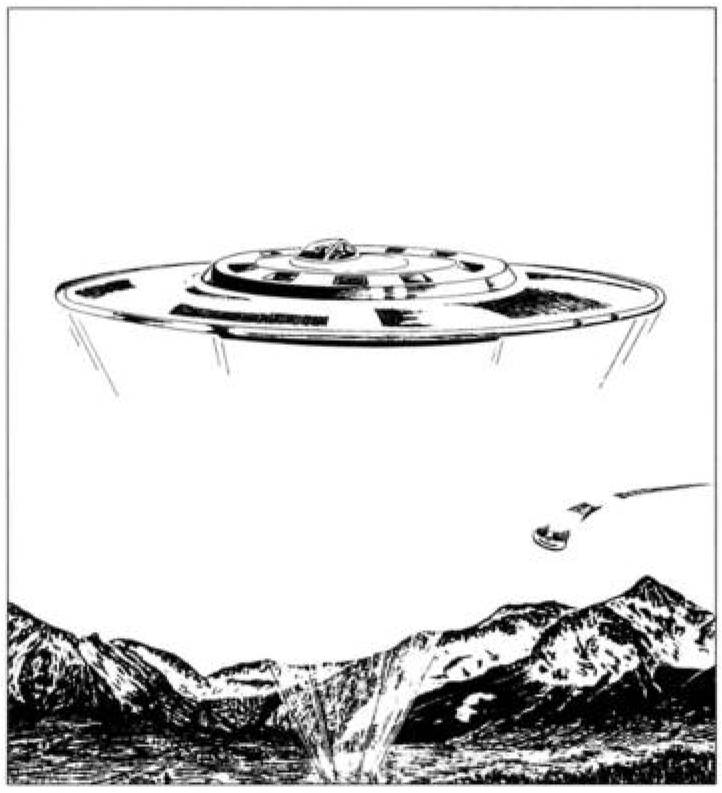
Controlling the aircraft in flight would have been achieved by the selective direction of exhaust gases and bending the jet flow by means of the Coanda Effect. Pitch and roll was regulated by the annular nozzles and the rear exhausts were responsible for yaw control. A second approach to flight control was considered. This used a shaped ring surrounding the edge of the entire aircraft, which acted as a selectively regulated Coanda exhaust system. This appears to have been developed from the system used on the smaller research aircraft and it may have been seen as the simpler solution. Unfortunately, wind tunnel tests showed that this design created excessive drag at supersonic speeds and the lower air intake ceased to function properly in level flight because exhaust gases were flowing across the bottom of the aircraft. A number of modifications were proposed which included the use of two small louvred exhaust vents positioned in the upper aerofoil to improve directional control, but the idea was finally dropped.

By 1956 the USAF is known to have expressed serious concerns about the reliability and combat survivability of the RFGT engine. It had always been know that without engine power this kind of aircraft would be impossible to fly and an emergency landing would be out of the question. Frost's team accepted this concern and set about



Project Y2 aircraft on patrol. USAF / Bill Rose





Above: **With reliability of the RFGT questionable, Frost and his team set about the design of an alternative propulsion system for Silver Bug, which made use of radially disposed conventional gas turbine engines.** Avro Canada

Left: **Project Y2 Silver Bug in VTOL operation from an improvised site. Note that this drawing shows gun ports in the leading edge.** USAF

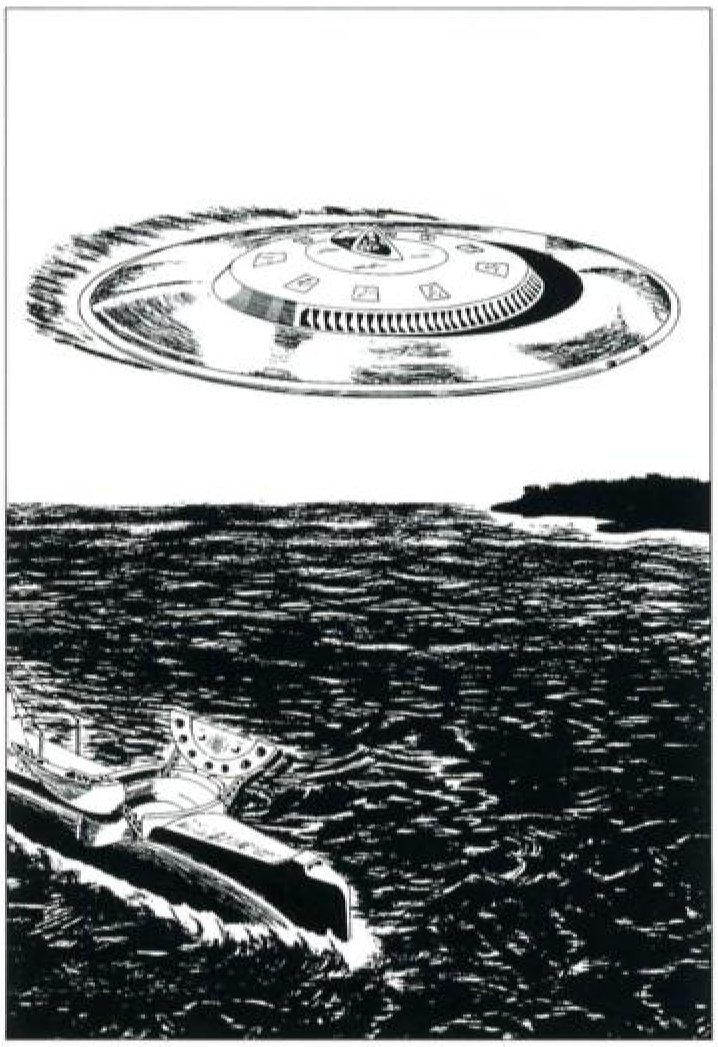
redesigning the RFGT aircraft to use conventional jet engines, providing some degree of redundancy. Gas turbines had undergone steady refinement since Project Y had started and Frost felt confident that a radially dispersed series of jet engines could be configured to provide adequate power without a major weight penalty.

Externally, Frost's new variant looked almost identical to the radial-engined vehicle, but internally it was designed to take six or eight conventional jet engines which were disposed around the central cabin in a pattern similar to the small research aircraft. With the airframe built to retain each engine in an individual section with accompanying fuel tanks, these units could easily be removed for inspection and maintenance purposes. As something of a bonus, this redesign increased fuel capacity and may have improved the aircraft's endurance.

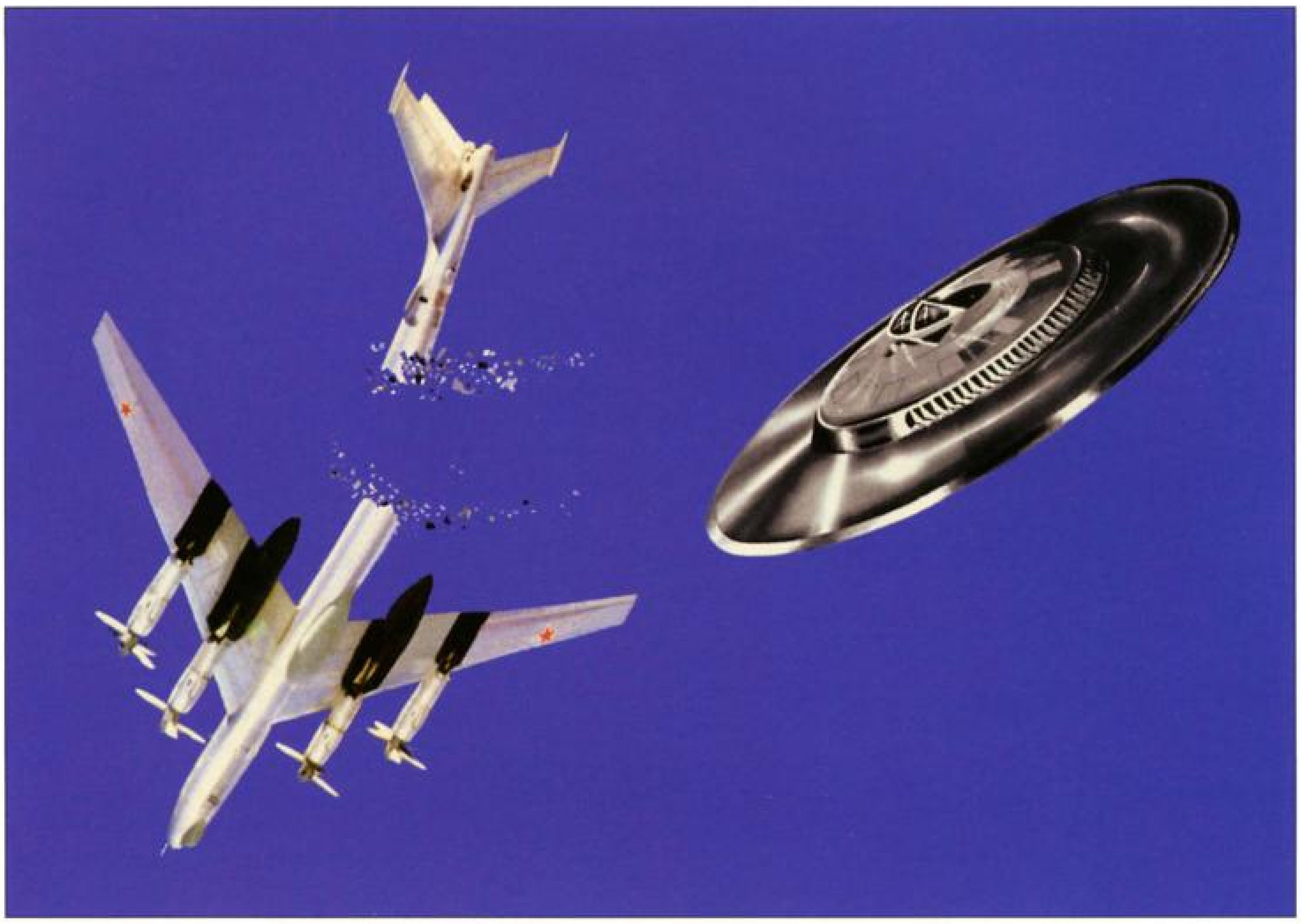
Exactly how the USAF intended to arm the RFGT-engined aircraft remains unclear, but there were ideas to fit two or four cannons. One unorthodox suggestion, which seems to have received very serious consideration, was to heavily armour the leading edge of the Silver Bug so it could be used to ram enemy bombers like a manned missile. The concept had already been explored by wartime German designers and became a feature of the experimental Northrop XP-79B flying-wing fighter. John Frost insisted that it would be possible to slice through an enemy bomber at speeds in excess of 2,000mph (3,218km/h) with absolutely no risk to the pilot and little prospect of causing any damage to the disc. This might have worked, but it is hard to imagine the average fighter pilot expressing great enthusiasm for the idea of smashing through a large Soviet bomber at Mach 2.75! USAF documents show that this aircraft was also envisaged as a light bomber although the question of how and where the appropriate stores were to be carried remains unanswered.

In addition to the USAF, RCAF and possibly the RAF, the US Navy showed great interest in Frost's flying disc and recognised its usefulness as a VTOL combat aircraft capable of operating from carriers, small ships and converted submarines with fully enclosed hangars. Frost had already concluded that the Soviets were operating their own version of Silver Bug from converted submarines and making overflights of US territory. He attributed the more reliable UFO sightings to be evidence of this activity.

Brief studies were also undertaken on larger and smaller variants of the advanced RFGT-powered design. One proposal was for a huge aircraft with a diameter of 100ft (30.5m) and a central thickness of 20ft (6.1m). This was envisaged as a long-range bomber, a reconnaissance vehicle or a transport aircraft. Details of the aircraft's propul-



Project Y2 Silver Bug aircraft operating from a specially converted US Navy submarine. USAF



Project Y2 Silver Bug slices through a Soviet *Bear* bomber using an intercept technique proposed by John Frost. The flying disc would be fitted with a hardened leading edge and the attack would take place at high supersonic speed. Frost maintained there would be very little prospect of damage to the Silver Bug aircraft and the pilot would be safe. Bill Rose

sion system are unknown but performance was optimistically suggested as a maximum speed of Mach 3, with a ceiling of 90,000ft (27,432m), a cruise altitude of 65,000ft (19,812m) and a range of 15,000 miles (24,140km). An unmanned Silver Bug was considered as a guided missile, presumably carrying a nuclear warhead, along with a small 6ft (1.8m) diameter version for battlefield use.

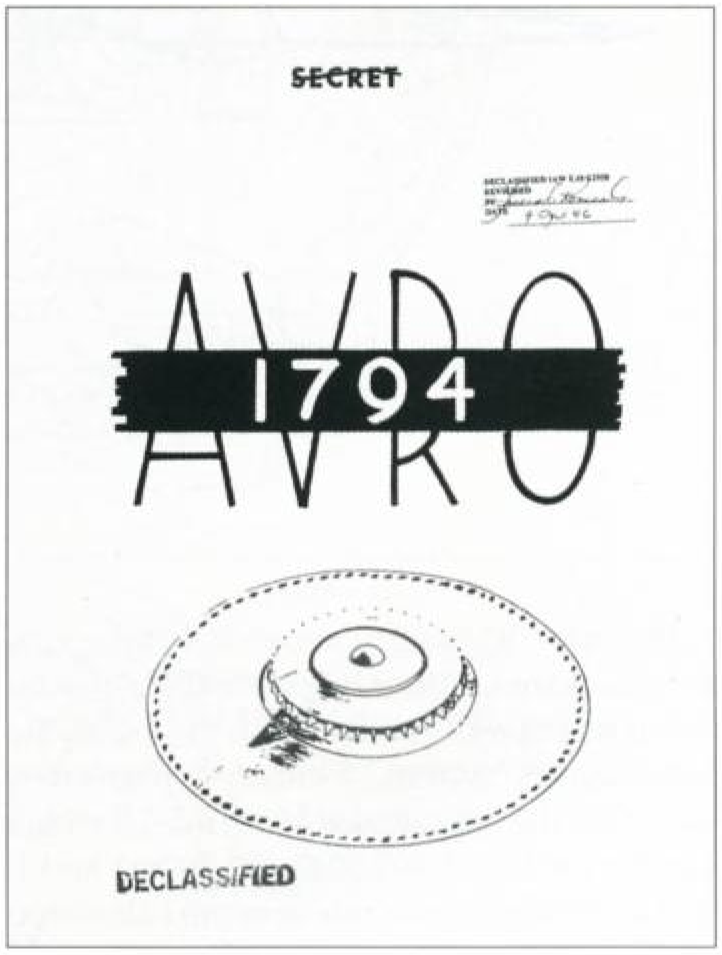
Project MX 1794

In 1954 the Air Research & Development Command at Wright-Patterson AFB funded a highly classified alternative to Silver Bug that was allocated the designation Project MX 1794. (Confusingly, the 1794 designation also appears on some Project Ladybird documents that refer to the earlier RFGT design.) Project MX 1794 promised a much higher level of performance than Silver Bug and by late 1955 this design had become Avro Canada's principal flying disc interceptor project, receiving the internal company designation PR (Proposal Reference) 89221.

The USAF prefix MX from this era is often associated with experimental missiles, but it was actually used to identify many other research projects and may simply be short for Military Xperimental. MX designated programmes ranged from radar systems and jet engines to aircraft like the Bell X-1 series (MX 984). In the case of MX 1794, the only unusual factor appears to be the allocation of an MX designation to a system under development by a foreign contractor.

Project MX 1794 featured a new type of turbo-ramjet propulsive system, which can be traced to 1953 when John Frost and Claude Williams began to consider alternatives to the RFGT. Their first proposal was a flying disc with an approximate diameter of 35ft (10.7m), which used a series radially dispersed axial flow gas turbines to drive a large compressor stage that revolved around the upper centre of the aircraft. In turn, this forced air through ducts to a series of flame holders around the circumference of the aircraft and the gas finally exhausted through shuttered ports that were adjusted to provide flight control. In addition to supplying air to each jet engine, the compressor would have turned fast enough to generate gyroscopic stability in much the same manner as the RFGT. In level flight the pilot could throttle back the turbojets and allow the ramjet function to take over. Normally ramjets only work at high speed but this propulsion system was intended to operate in ramjet mode at all speeds, including hover!

Two further designs followed, with different engine layouts and alternative pilot positions, but the fourth study became Project MX 1794, which combined aspects of all the earlier turbo-ramjet studies with elements of Silver Bug. Project MX 1794 was finally selected by the USAF as a follow on to Silver Bug and in 1955 Quarles allocated a further $750,000 to the programme. In September 1955 a 5ft (1.5m) diameter 1/6th-scale model of Project 1794 (the MX designation now seems to have been discarded) was shipped to Wright-Patterson AFB for wind tunnel testing, while engineers began to assemble an engine test rig at Malton.



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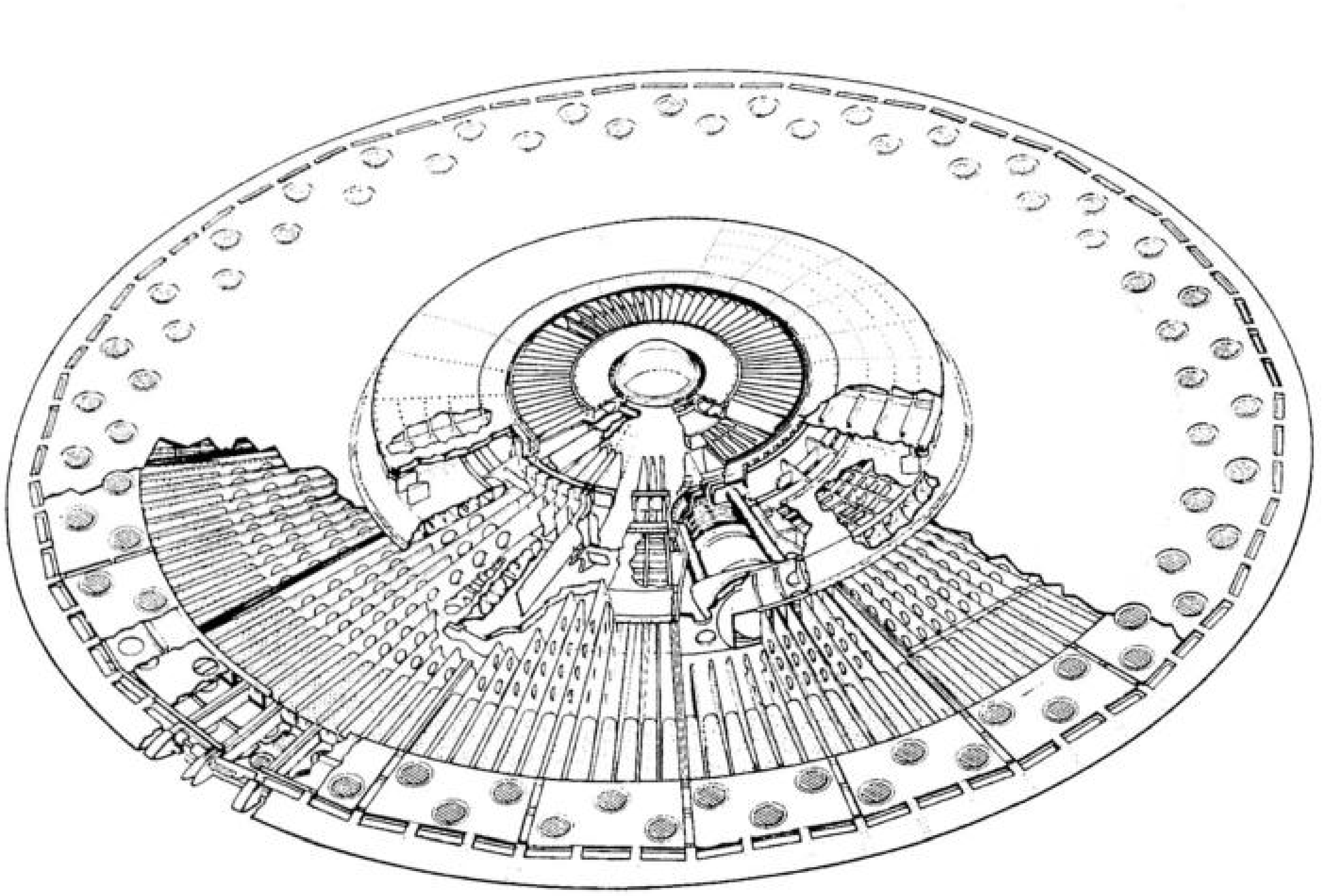
AVRO

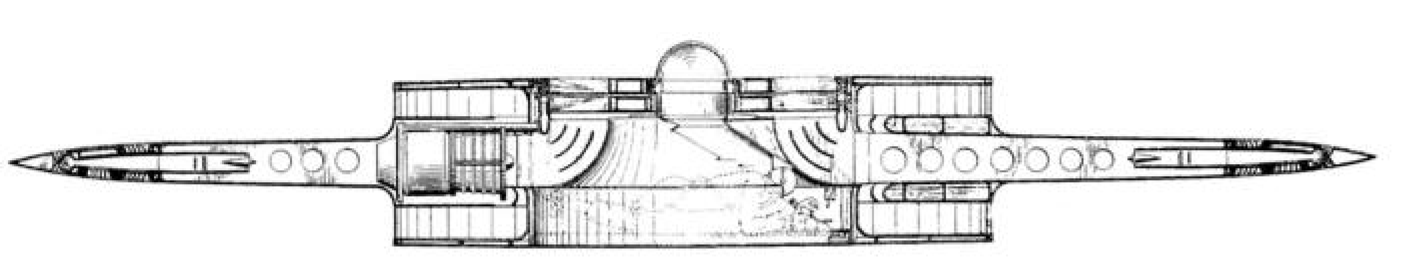
1794

DECLASSIFIED

Avro Canada 1794 document front cover. USAF



An early configuration for the MX 1794 aircraft.
Avro Canada



Avro Canada MX 1794 design evolution.
via Bill Rose

Project 1794 fulfilled much the same role as the advanced Silver Bug aircraft, but it used the more powerful and possibly more reliable turbo-ramjet system. Estimated maximum speed for the aircraft was Mach 3.5-4.0 with a service ceiling of 105,000ft (32,000m) and it had a very impressive rate of climb calculated at 3 minutes to 75,000ft (22,860m). The aircraft was expected to attain Mach 2.25 supersonic cruise at 90,000ft (27,432m) for 37 minutes and, because the maximum weight was 27,322 lb (12,393kg) fully fuelled, a range of 1,000 miles (1,609km) was anticipated. Dimensions of the 1794 aircraft were 35ft 3½in (10.76m) in diameter and 7ft 8½in (2.35m) from the lower surface to canopy top.

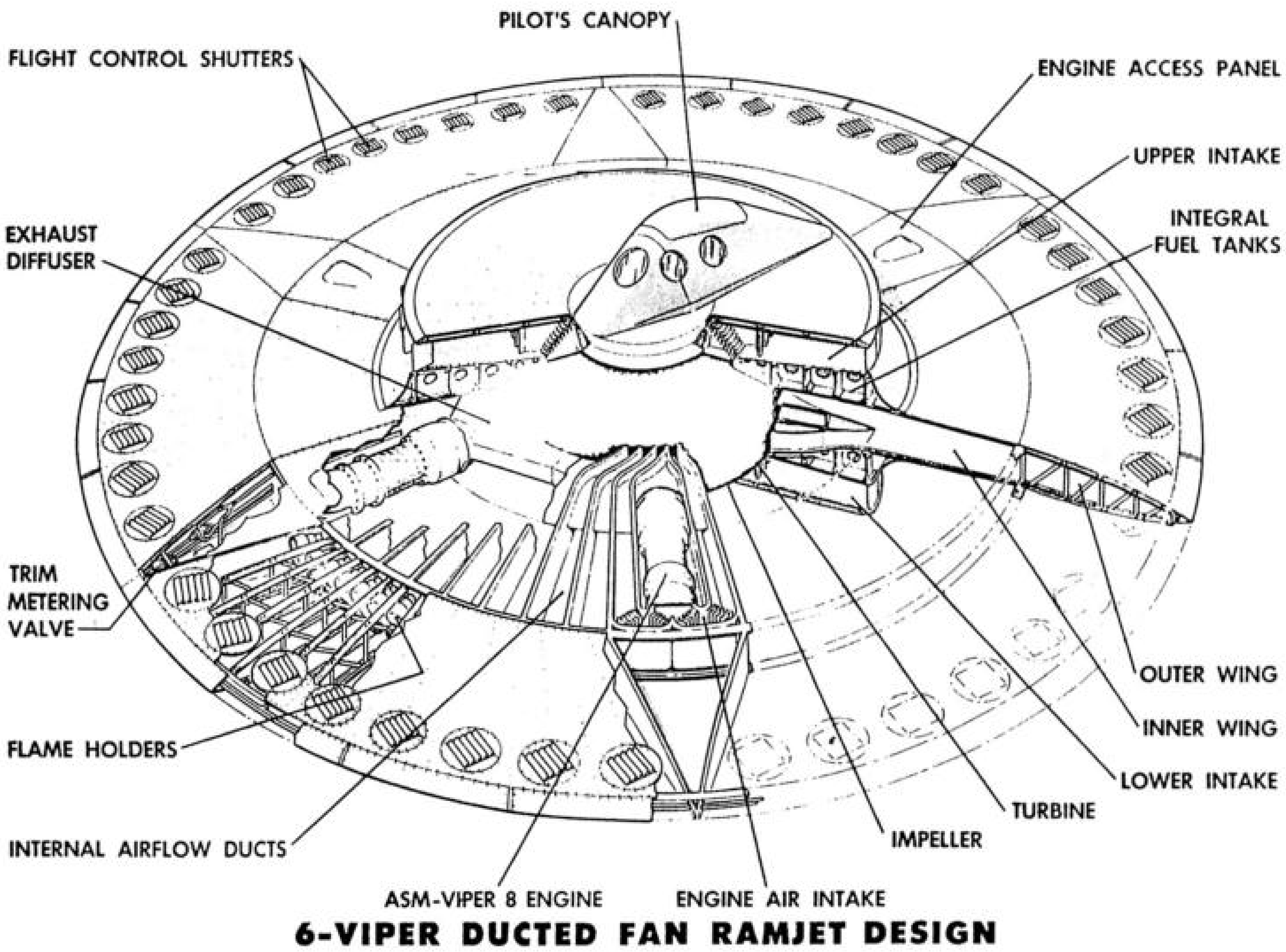
Project 1794 used six Armstrong Siddeley Viper turbojets with their exhausts facing inwards to drive two 8ft (2.44m)-diameter contra-rotating centrifugal impellers that powered the ramjet system. On their own the Viper turbojets produced 9,000 lb (40kN) of static thrust, but as an overall system the ducted fan ramjet was expected to provide a variable range of thrust from 17,800 lb to 32,750 lb (79kN to 145kN). During the planned test flights the exhaust temperatures would have been initially restricted to 1,200°K, providing a Mach 1.6 capability, but this would have been progressively uprated to 1,700°K, which was calculated to provide a speed of at least Mach 3.7 at extreme altitude. While there was probably some degree of redundancy in the propulsion system and the failure of one turbojet might have been tolerable in an emergency, the aircraft was still totally dependent on engine power for stability and control.

During an evaluation of 1794 Edward H Schwartz, of the Aircraft Laboratory, said, 'Should a complete power failure or exhaustion of fuel occur, it would be impossible to make a forced landing. Whether sufficient controllability would exist even with ram-air at high forward speeds, to enable the pilot to establish favourable ejection conditions is questionable'. By December 1956 the engine test rig that represented about three-quarters of the aircraft had been completed and was undergoing tests at Malton.

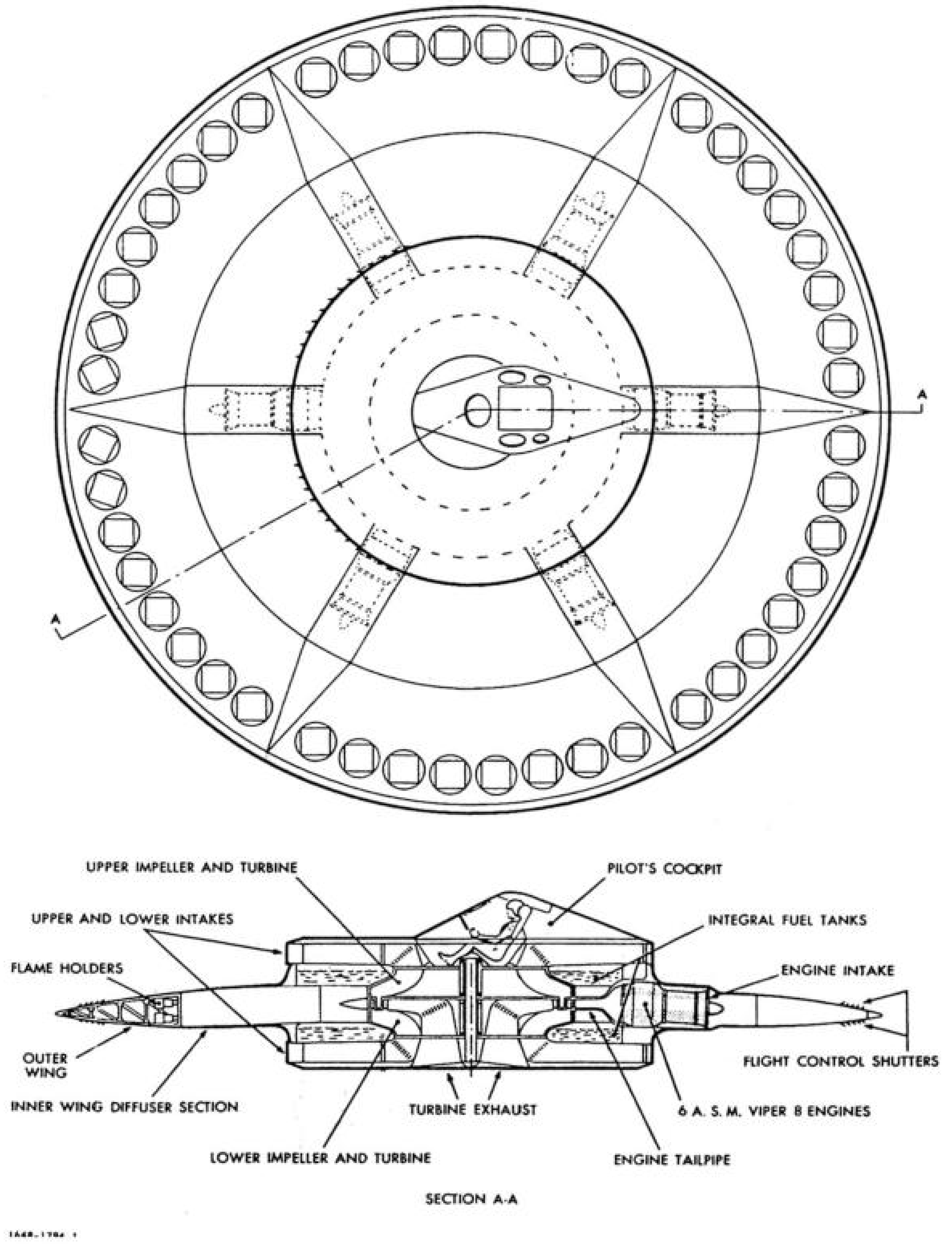
At this stage major concerns were being expressed by USAF scientists, who felt that the 140dB noise level produced by the Vipers was excessive and would create a totally unacceptable cockpit environment. Other problem areas concerned engine heating and temperatures in the special combustors that had been custom manufactured in England, and the suitability of various metals for exhaust system sections and the controllable outlet vents. Thermal fatigue within the propulsion system represented a substantial worry but new high temperature alloys were being developed during the mid-1950s and it seems likely that suitable materials would have been found.

As with Silver Bug it was evident that prolonged supersonic flight would heat the airframe and skin to very high temperatures that might prove unacceptable. To cope with this some airframe parts would have been made from temperature-resistant Nimonic (Nickel-Chromium) alloys while the skin of the air-

This drawing shows the principal features of the Avro Canada MX 1794 which used a very powerful turbo-ramjet propulsion system. USAF


PILOT'S CANOPY
FLIGHT CONTROL SHUTTERS
ENGINE ACCESS PANEL
UPPER INTAKE
INTEGRAL FUEL TANKS
EXHAUST DIFFUSER
TRIM METERING VALVE
OUTER WING
INNER WING
LOWER INTAKE
FLAME HOLDERS
TURBINE
IMPELLER
INTERNAL AIRFLOW DUCTS
ASM-VIPER 8 ENGINE
ENGINE AIR INTAKE
6-VIPER DUCTED FAN RAMJET DESIGN

Avro Canada MX 1794 drawings. USAF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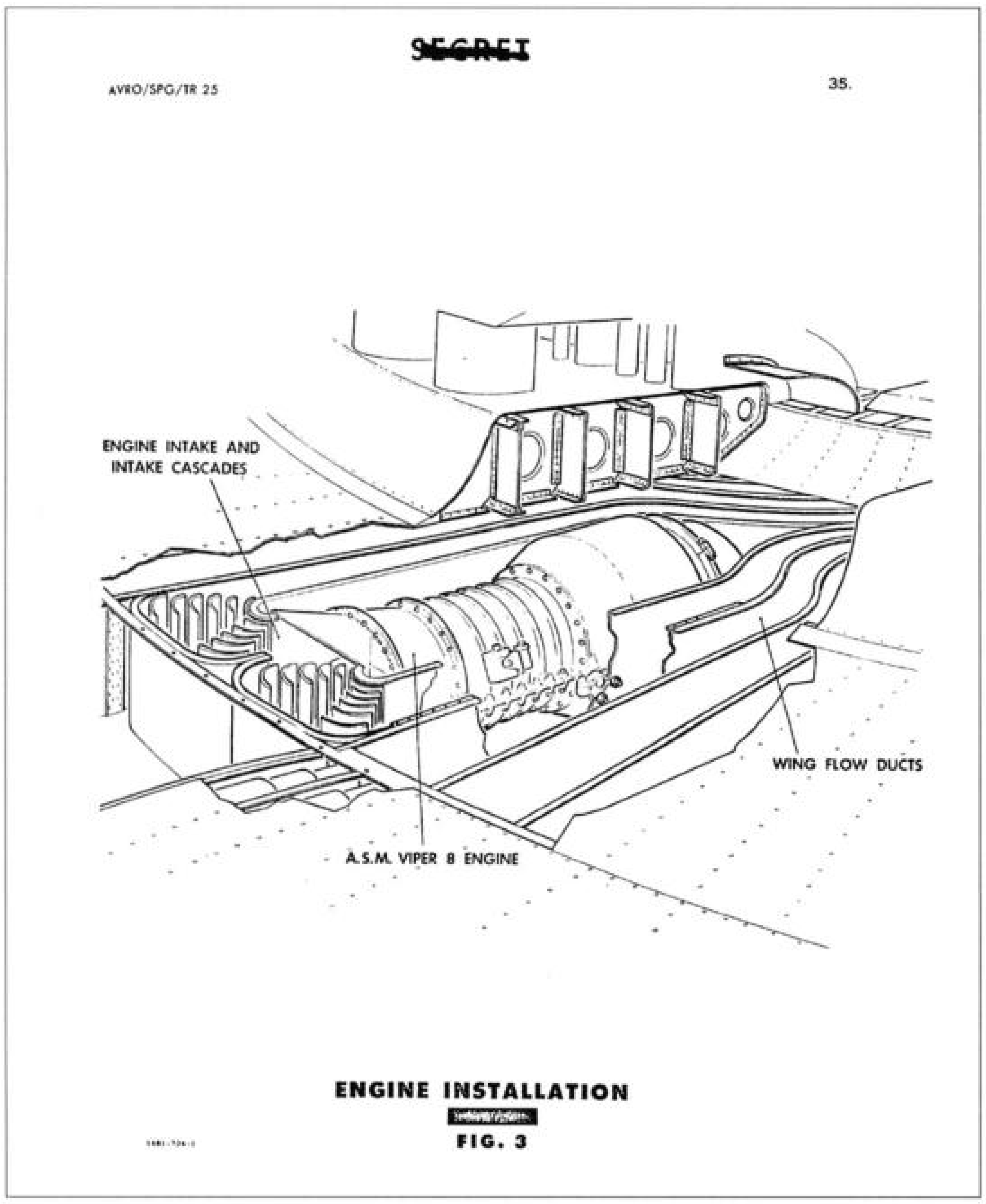
PILOT'S COCKPIT
UPPER AND LOWER INTAKES
INTEGRAL FUEL TANKS
FLAME HOLDERS
ENGINE INTAKE
OUTER WING
FLIGHT CONTROL SHUTTERS
INNER WING DIFFUSER SECTION
TURBINE EXHAUST
6 A. S. M. VIPER 8 ENGINES
LOWER IMPELLER AND TURBINE
ENGINE TAILPIPE
SECTION A-A

craft was to be entirely fabricated from 300-series stainless steel of 0.43in (10.92mm) thickness. Studies conducted by the Hughes Aircraft Company and Ramo-Wooldridge Corp in 1956 indicated that the radar/fire control system for this aircraft would weigh 2,055 lb (932kg) and require 41ft^3 (1.16m^3) of space. There was also the question of exactly where to position the radar dish at the front of the aircraft.

As an interceptor Project 1794 would have been armed with a 20mm Gatling Gun and two Sparrow air-to-air missiles (AAMs) or conceivably two AIR-2A Genie rockets with nuclear warheads or two long-range AIM-26A nuclear-tipped Falcon AAMs. The USAF did not favour carrying external weapons and fuel tanks because the aircraft's performance was dependent on its aerodynamic cleanliness, but it finally decided that the easiest option was to mount both missiles on external launch rails. This gave a noticeable reduction in performance when the additional drag was taken into account. As a fully equipped interceptor the aircraft would weigh approximately 32,000 lb (14,514kg).

Studies were conducted into adapting the Project 1794 aircraft for daylight high-altitude photo-reconnaissance operations and an internal camera system similar to that used in the U-2 spyplane would have been carried, although no technical details of this variant have been released by the USAF. Interesting enough, Dick Cantrell of Lockheed's Skunk Works is said to have once remarked that a flying saucer shape represented the ultimate in low observability and this wouldn't have escaped the attention of designers during the 1950s. The possibility of turning Project 1794 into an interdictor or light bomber was examined briefly, but any recommendations are unknown. Needless to say, any ordnance would have been carried externally.

A more robust cockpit canopy than that on Silver Bug was proposed for the operational 1794 aircraft, which would have coped well with sustained high-speed flight, although visibility might have been degraded by the use of extra metal sections. The USAF recognised that any pilot flying a discplane with a centrally located cockpit would experience serious visibility restrictions because a good proportion of the ground is obscured in level flight, so a periscope system was suggested to provide a view below the aircraft. As Project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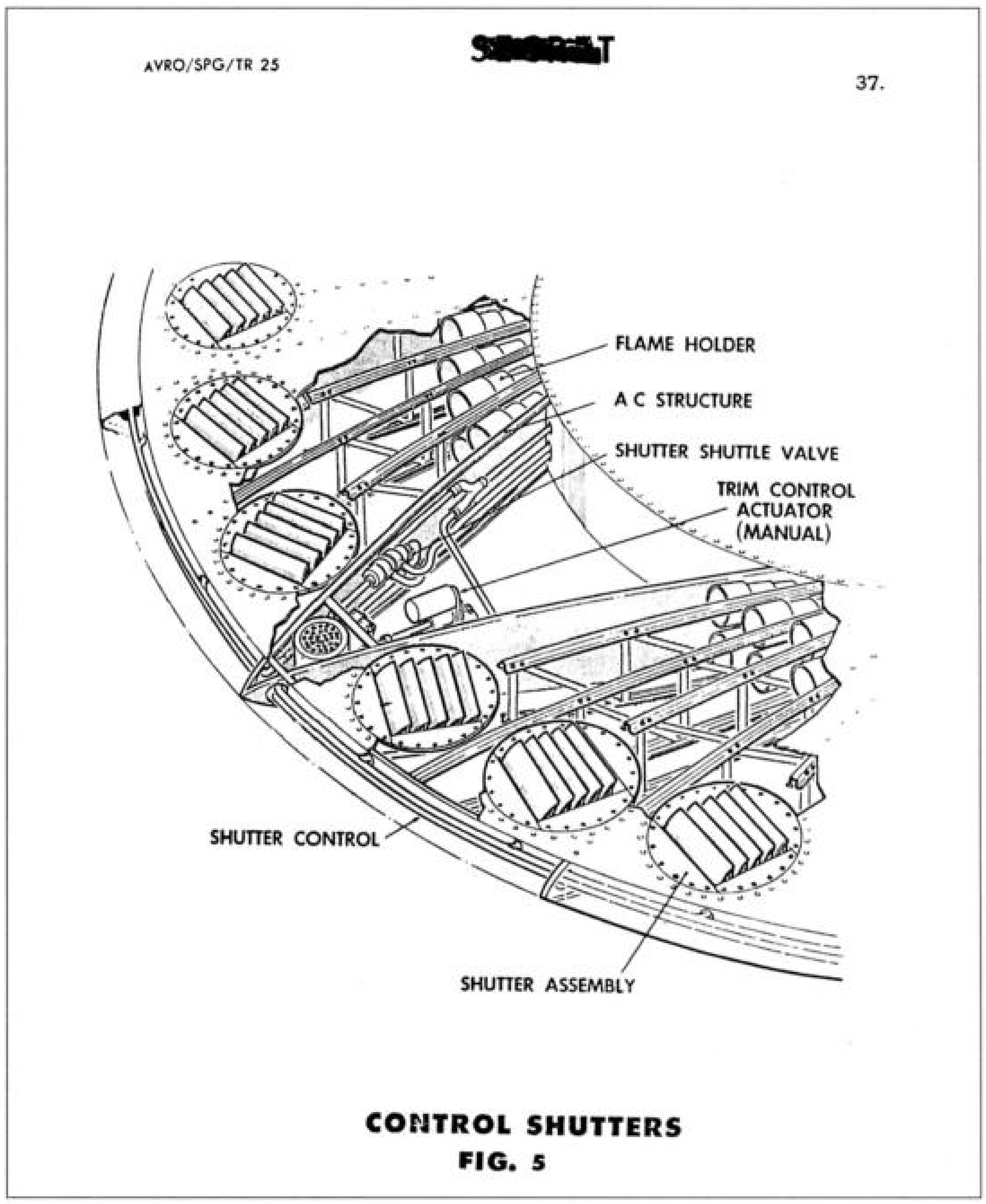
AVRO/SPG/TR 25
35.
ENGINE INTAKE AND INTAKE CASCADES
WING FLOW DUCTS
A.S.M. VIPER 8 ENGINE
ENGINE INSTALLATION
[redacted]
FIG. 3

ASM Viper 8-engine installation for the Avro Canada MX 1794 flying disc. USAF

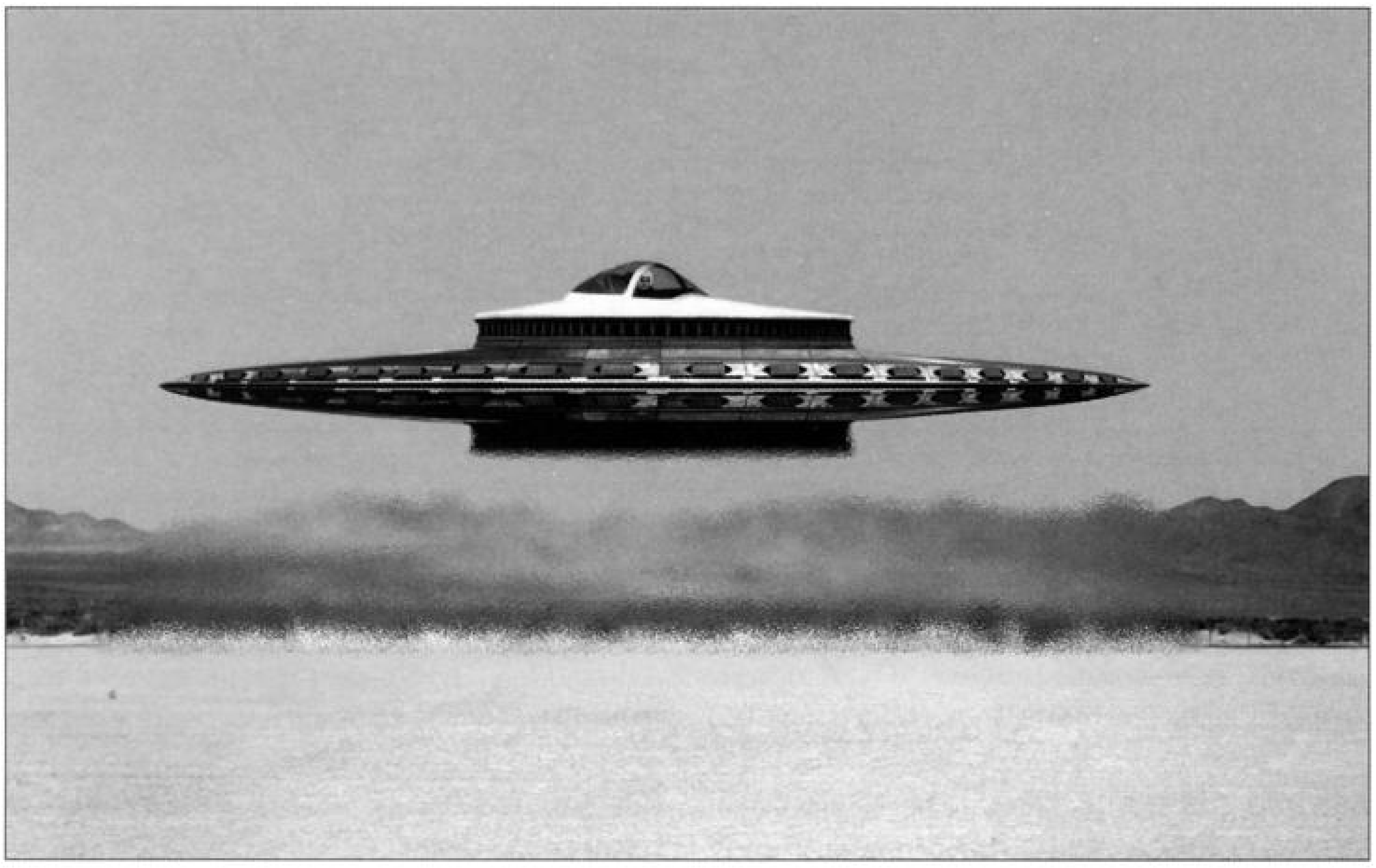

AVRO/SPG/TR 25
[redacted]
37.
FLAME HOLDER
A C STRUCTURE
SHUTTER SHUTTLE VALVE
TRIM CONTROL ACTUATOR (MANUAL)
SHUTTER CONTROL
SHUTTER ASSEMBLY
CONTROL SHUTTERS
FIG. 5

Detail of the complex exhaust shutter control system proposed for the MX 1794 aircraft. USAF

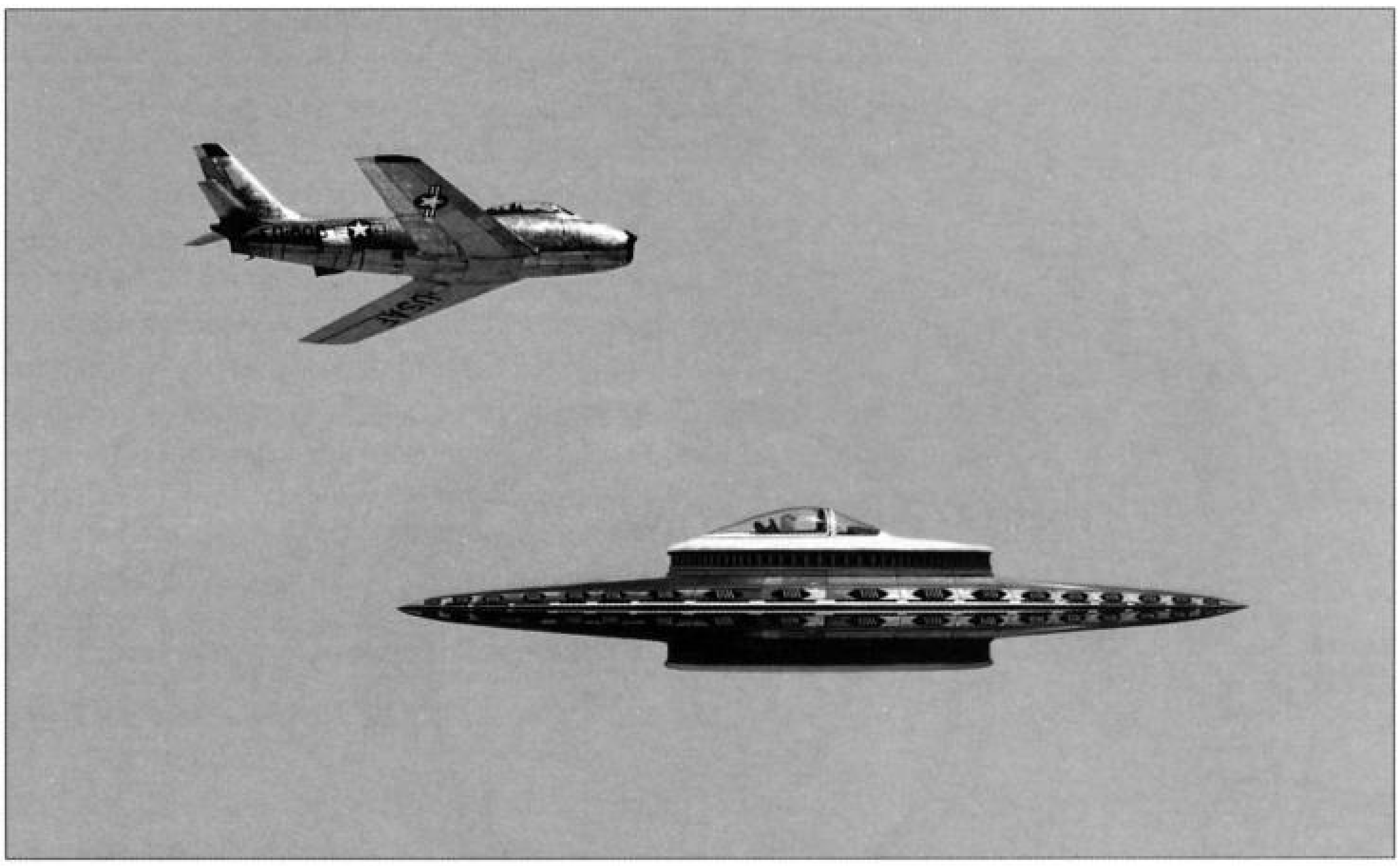
1794 proceeded the USAF specified three retractable landing legs to support the aircraft at 2ft (0.6m) above the ground and official documentation shows that wheels and rubber tyres were then added to improve ground handling. Many of the questions raised by Silver Bug also apply to Project 1794. How far did the project actually progress, and did it move sideways into the black domain?

At a review body meeting held at Wright-Patterson AFB on 4th November 1955, Avro Canada's Vice-President Fred T Smye said that his company was ready to begin construction of a 1794 prototype. Smye told USAF officials that he was so confident of success he would advise the Avro board to put up $4.5 million to ensure the aircraft was built. The USAF then calculated that full development of the aircraft over the next five years would cost around $50 million, which was certainly an acceptable figure for any 1950s high-performance aircraft.

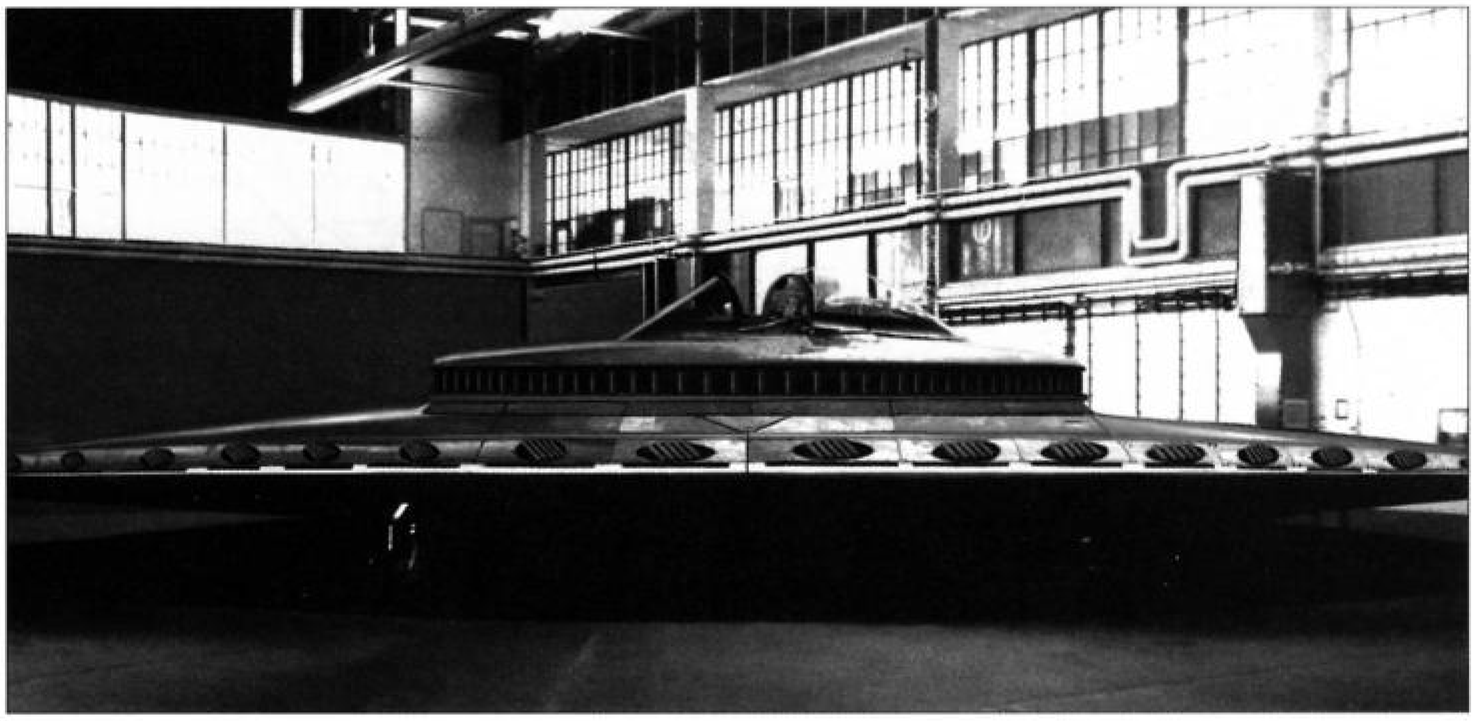
One month later Avro advised the USAF that three-quarters of the aircraft had been completed and, in July 1956, USAF Major J W Frost from the Wright-Patterson Air Development Center (no apparent connection to John Frost) visited Avro to discuss the construction of a second prototype. Wind tunnel tests of the 1/6th scale model had now been completed at the Wright Air Development Center and ground effect studies were under way. However, on 1st August 1956 MIT informed the USAF of their separate wind tunnel tests on 1794 models and a major review of the project followed almost immediately. MIT scientists had decided that the lift/drag (l/d) ratio of a circular planform wing could



A photo-realistic simulation of the Avro Canada MX 1794 undergoing secret flight-testing at a remote USAF facility. Bill Rose



A simulation of the Avro Canada MX 1794 undergoing a secret test flight accompanied by a USAF chase plane. Bill Rose



A photomontage showing a completed prototype Avro Canada MX 1794 fitted with a high-visibility cockpit canopy for preliminary testing. Bill Rose

not match a properly designed swept wing at supersonic speeds. They also advised the Wright-Patterson project office that the l/d ratio at low subsonic speeds would be unsatisfactory.

The USAF seems to have accepted this but felt that the astonishing thrust/weight ratio of the Project 1794 aircraft more than compensated for any deficiencies. By the end of that month, wind tunnel testing had switched to NACA's Ames facility in California and Project 1794 seemed to be back on course.

On 11th October 1956, during a presentation to the US Navy at the Pentagon, Admiral Russell was advised that a Project 1794 prototype would be completed by January 1957. Then the programme was quietly dropped ... or so we are told! Despite the obvious disinformation and intentional confusion generated by the multiple use of designations for the same programme, there are documents which show ongoing discussion of a ramjet-powered flying disc as late as March 1959. Meanwhile, another project known as PV.704 was getting under way and this briefly used the title Project 1794, which then became Performance Research System Nr 453L and finally WS-606A.

WS-606A

In addition to developing the USAF's MX 1794, the SPG were also working on a broadly similar proposal for the RCAF called Private Venture 704 (PV.704). By 1955 the USAF and CIA were looking for a successor to the high-altitude Lockheed U-2 spyplane and PV.704 caught their attention. This design seemed to promise the kind of performance the USAF sought for its next-generation spyplane. Essentially, PV.704 was a variant of MX 1794 with a totally different cockpit that took the form of a central dome with viewing ports for the pilot. After carefully examining this alternative concept, various design changes were suggested and the dome-shaped cockpit was replaced with a fuselage section containing extra engines for level flight and additional storage space.

This revision clearly won favour with the Pentagon, who made substantial black budget funding available for further development and renamed PV.704 as Weapons System 606A (WS-606A). Two versions of WS-606A emerged from the initial studies. The first, called Configuration A, was a single-seat aircraft with a completely circular wing, married to a compact tailless fuselage. Power was provided by six side-by-side Armstrong Siddeley Viper jet engines and a central RFGT fed by large over-wing air intakes.

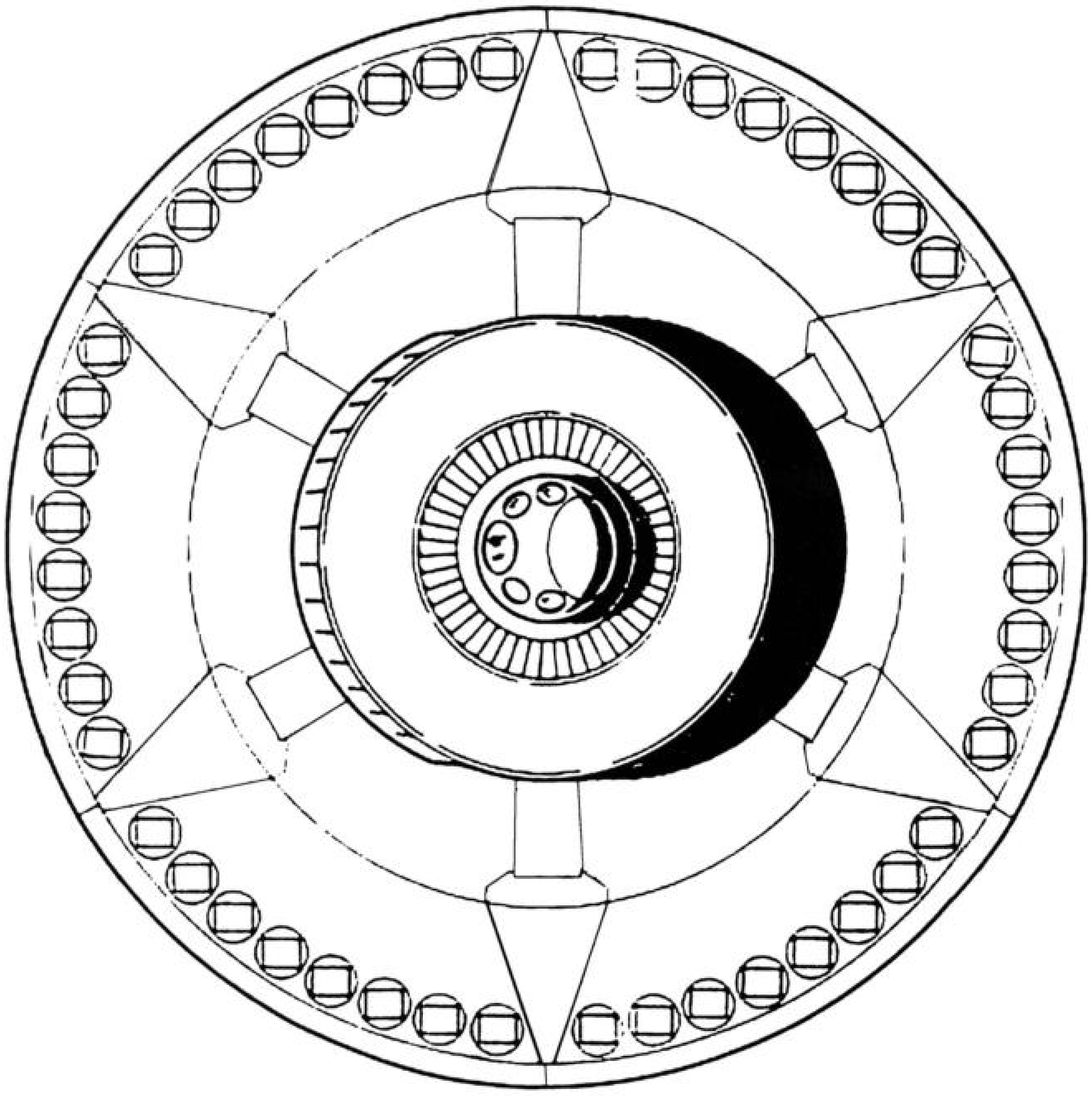
The radial flow ducted fan was intended to provide full VTOL, although it was later realised that the aircraft's endurance could be substantially improved by using a rolling take-off. This was called Ground Effect Take-off (GETO) and calculations suggested it would increase the mission range by 35%. The WS-606A had a length of 37ft (11.28m) and the circular wing spanned 29ft (8.84m). A minor variant of this design shows the same aircraft with four turbojets instead of six, but otherwise it appears virtually the same. WS-606A Configuration A was expected to attain Mach 4 at an altitude of 95,000ft (28.953m), which was far in excess of the most advanced combat aircraft then under development.

The second version of the WS-606A aircraft, known as Configuration B, was approximately the same size but used a different propulsion system layout. This comprised two unspecified Pratt & Whitney jet engines coupled to a RFGT located in the centre of the circular wing. This system was expected to provide a total thrust of 55,000 lb (244kN). Air for the engines was drawn through a nose inlet fitted with a conical centre-body and the fuselage looked slightly reminiscent of the CF-105 Arrow. This version of WS-606A carried a pilot and a navigator. Three sets of double wheels supported the aircraft and ground clearance would have been absolutely minimal, with just a few inches to spare. Gross weight was calculated at 65,000 lb (29,483kg).

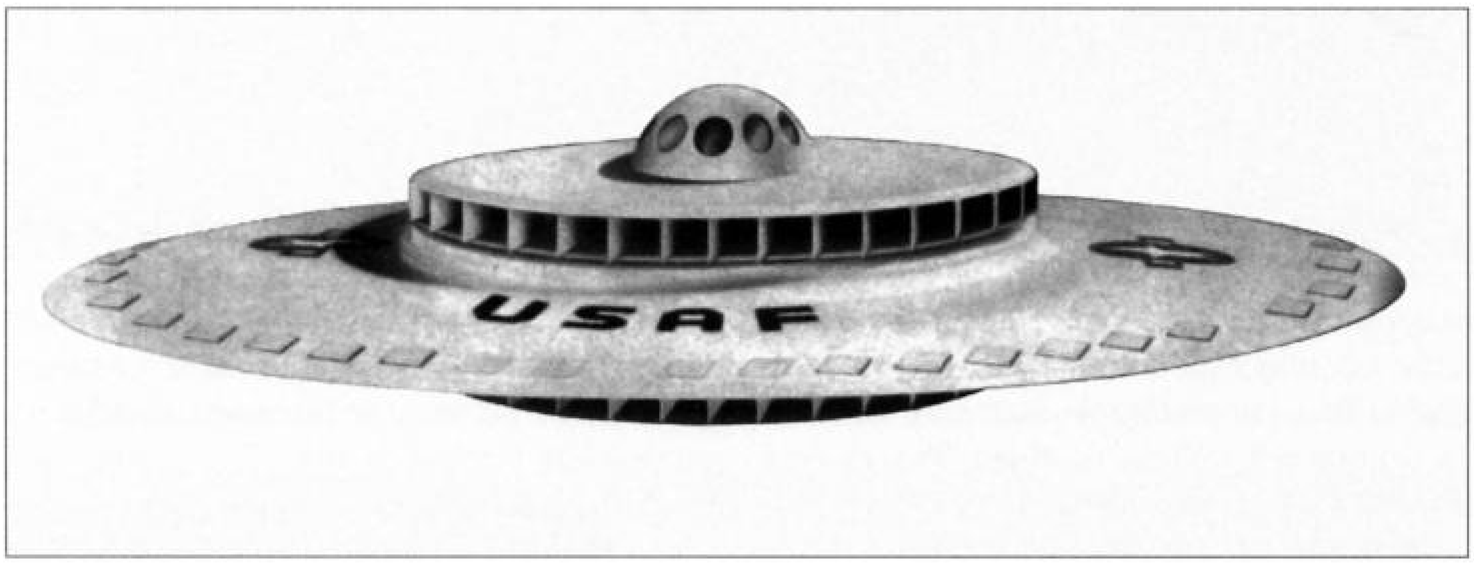
As research continued more realistic estimates started to emerge; these indicated a maximum speed of Mach 2.5, a ceiling of 65,000ft (19.812m), a combat radius of 800 miles (1,287km) and a ferry range of 3,300 miles (5,310km). By the time the design had been revised as Configuration B, the performance figure had been re-estimated as a maximum speed of Mach 2, with a combat radius of about 500 miles (804km) using VTO and 700 miles (1,126km) using GETO. The payload of this aircraft has been quoted in USAF documents as a very modest 1,000 lb (453kg). So, if Configuration B had been configured as an interceptor with two air-to-air missiles and associated electronics, the extra weight would easily have exceeded this figure.

In the light bomber role a payload of 1,000 lb (456kg) would have been inadequate for any realistic mission and the carriage of just one nuclear weapon would have exceeded this limit. A typical free-fall tactical nuclear bomb of that era (like the US Mk 5 or similar British Red Beard) weighed approximately 1,900 lb (861kg); carrying one of these would have created a noticeable drop in performance. But the real puzzle is trying to figure out how the designers planned to carry any external ordnance, which would have been almost impossible.

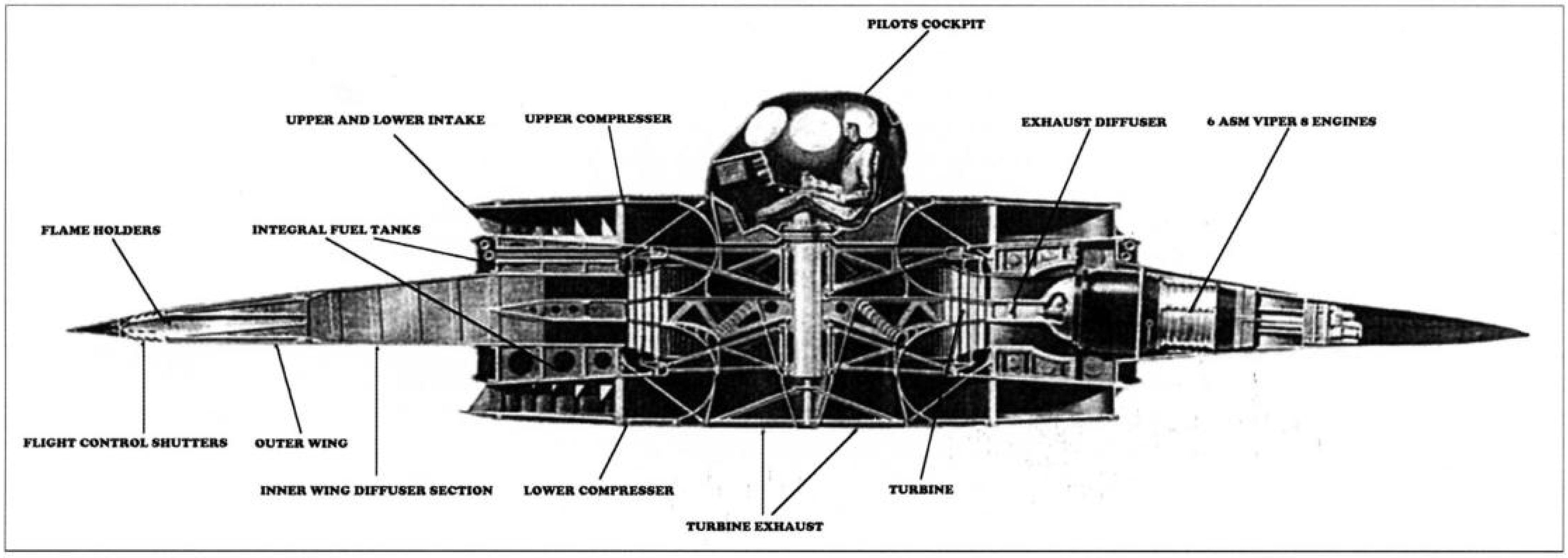
Early drawings of the WS-606A suggest that an extra dorsal area behind the cockpit would have been fitted to production aircraft for additional fuel and ordnance. However, this area seems too small for air-to-surface missiles and would obviously be unsuitable for a small bomb load. Perhaps there were plans to mount two AAMs above the wing like the Anglo-French Jaguar strike-aircraft, but it



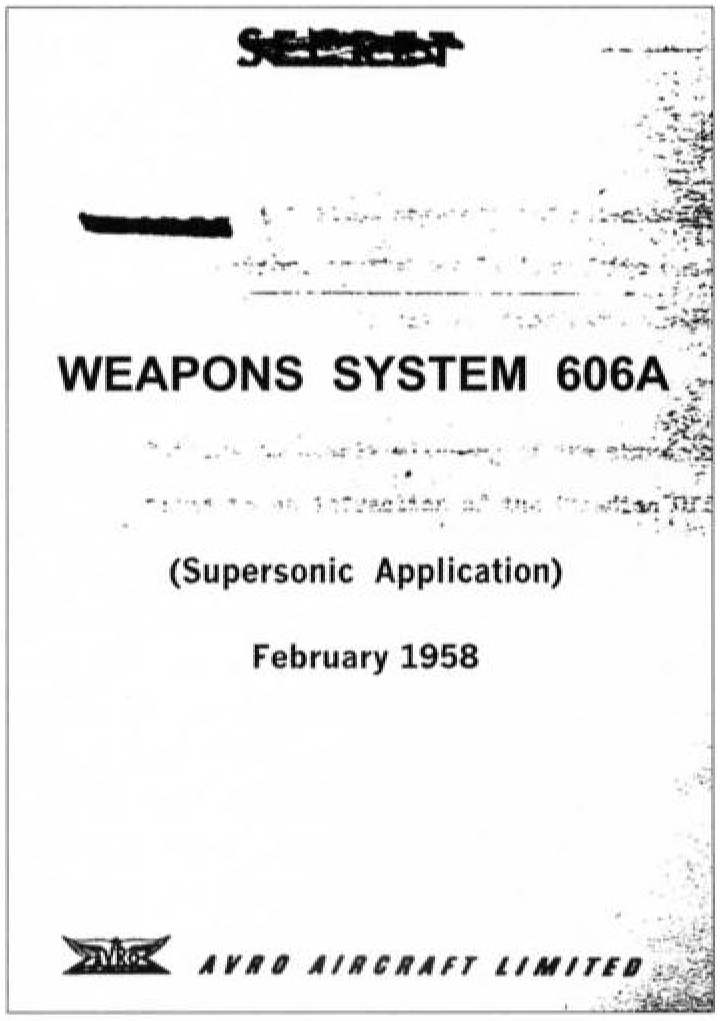
Planform view of the Avro Canada PV.704 showing the proposal for a dome-shaped cockpit canopy. USAF



Avro Canada PV.704 with dome-shaped cockpit canopy in USAF markings. USAF


PILOTS COCKPIT
UPPER AND LOWER INTAKE
UPPER COMPRESSER
EXHAUST DIFFUSER
6 ASM VIPER 8 ENGINES
FLAME HOLDERS
INTEGRAL FUEL TANKS
FLIGHT CONTROL SHUTTERS
OUTER WING
INNER WING DIFFUSER SECTION
LOWER COMPRESSER
TURBINE
TURBINE EXHAUST

A cross-section of the Avro Canada PV.704 showing the pilot seated directly above the upper turbine bearing. USAF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WEAPONS SYSTEM 606A

(Supersonic Application)

February 1958

AVRO AIRCRAFT LIMITED

WS-606 document front cover. USAF

Avro Canada Special Projects History

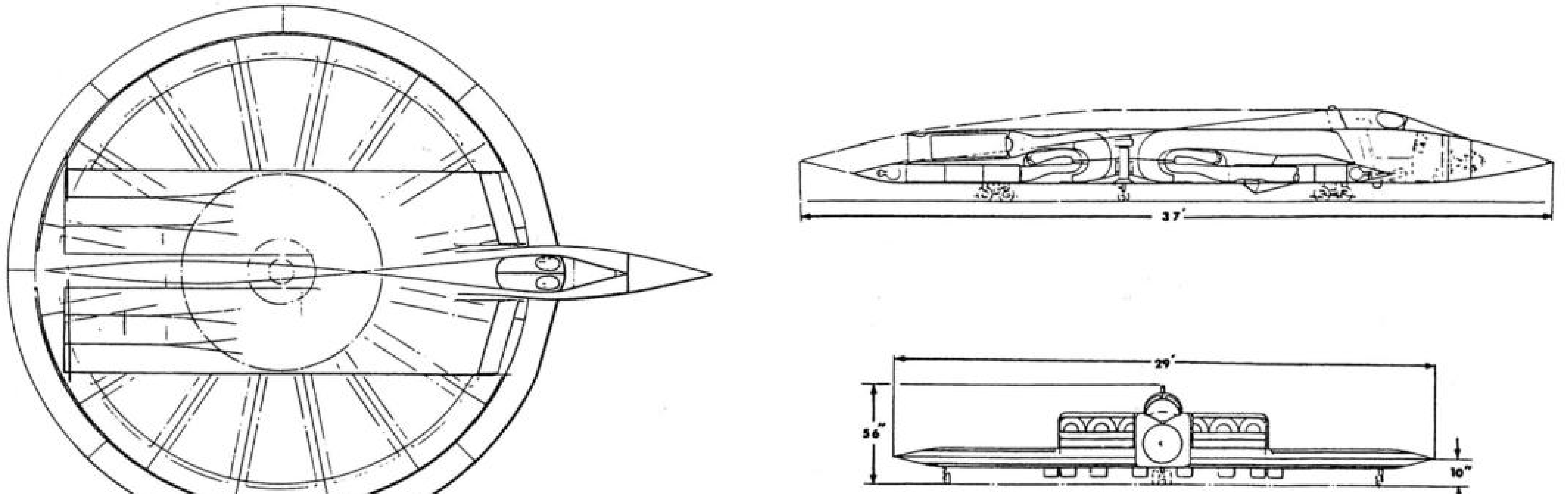
	1947	British engineer John C M Frost joins Avro Canada Ltd as Chief Designer for the CF-100 fighter project.
Mar	1952	Avro Canada begins Project Y. RCAF provides $410,000 CDN.
Feb	1953	*Toronto Star* carries brief description of Project Y.
Mar	1953	Avro (UK) Study a Project Y alternative called P.724.
Apr	1953	Project Y mock-up shown to VIPs.
	1953	Frost attends secret meeting with German flying disc engineer.
Mar	1954	Project Y cancelled. No further RCAF involvement.
Jul	1954	USAF takes over Project Y. Pentagon provides $784,492 US. New programme called Project Y2 Ladybird.
	1955	Ladybird codename changed to Silver Bug.
	1955	Silver Bug research aircraft expected to fly.
	1955	Project MX 1794 development started.
Dec	1955	Avro fund Project PV.704 concept. $2,500,000 CDN.
	1956	Mock-up of Project 1794 possibly completed.
Mar	1957	USAF take over PV.704 as WS-606A. $1,118,292 US.
Jun	1957	Components manufactured for Project 1794 Prototype.
Jan	1958	Work starts on supersonic WS-606A Prototype.
Feb	1958	Avrocar proposed for US Army.
Mar	1958	USAF suggests halting supersonic WS-606A project.
Mar	1958	Avrocar study undertaken for US Army. $696,383 US.
	1958	Mock-up of Avrocar built.
May	1958	USAF Contract (AF-33(600)-3796) awarded to Avro for the construction of one Avrocar demonstrator. $2,102,197 US.
Mar	1959	Second Avrocar commissioned by USAF. $1,775,000 US.
Feb	1959	Supersonic WS-606A discontinued by Avro.
May	1959	Avrocar #1 rolled out. Trials started in June 1959.
Aug	1959	Avrocar #2 rolled out. Trials started in Nov 1959.
July	1960	USAF contract, of unknown value, for continuation of Avrocar.
	1960	Advanced Avrocar proposed.
Dec	1961	Avrocar Programme ends.

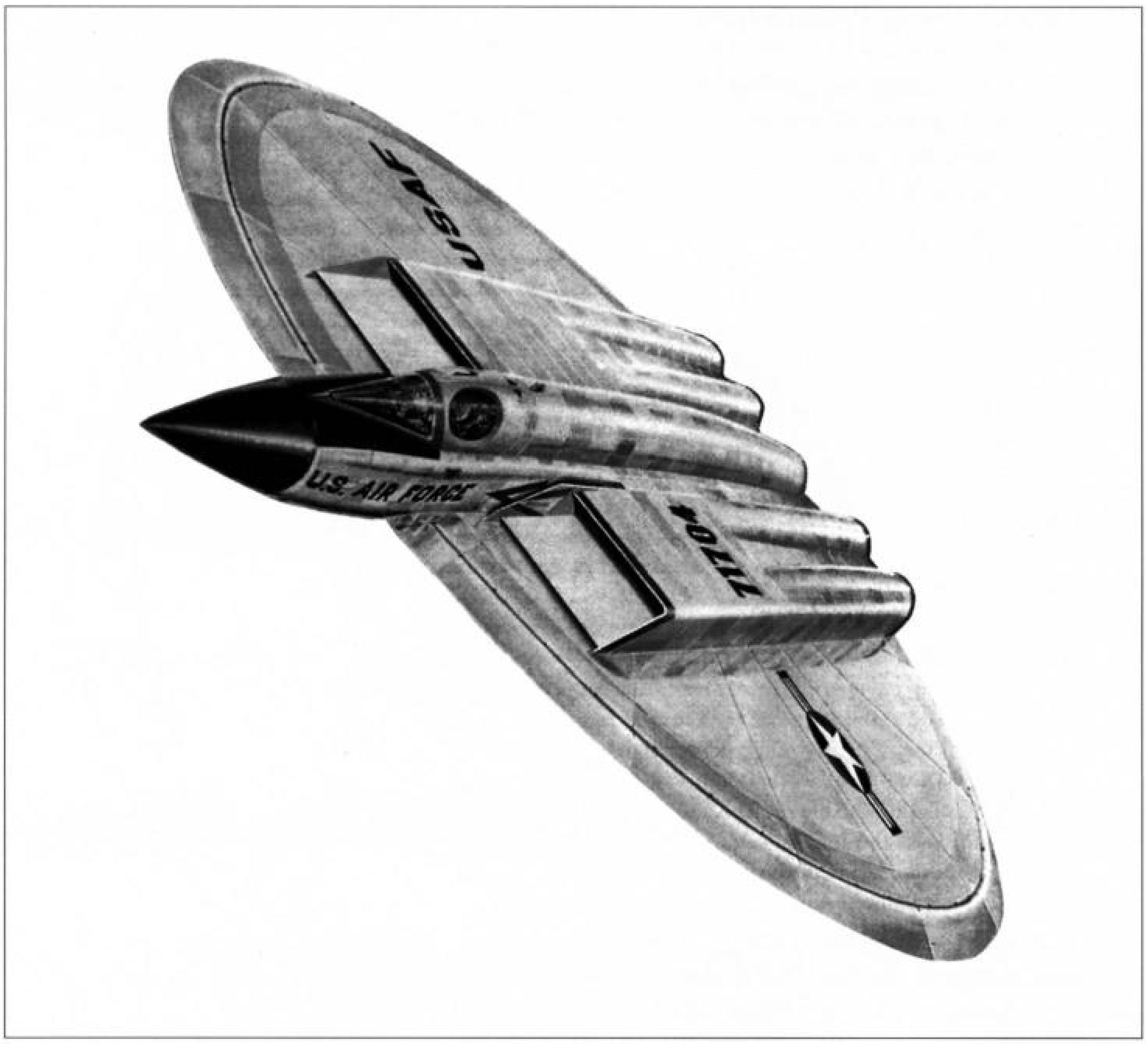
appears more likely that this design was always intended to be a daylight photo-reconnaissance aircraft and the multi-role capability never existed.

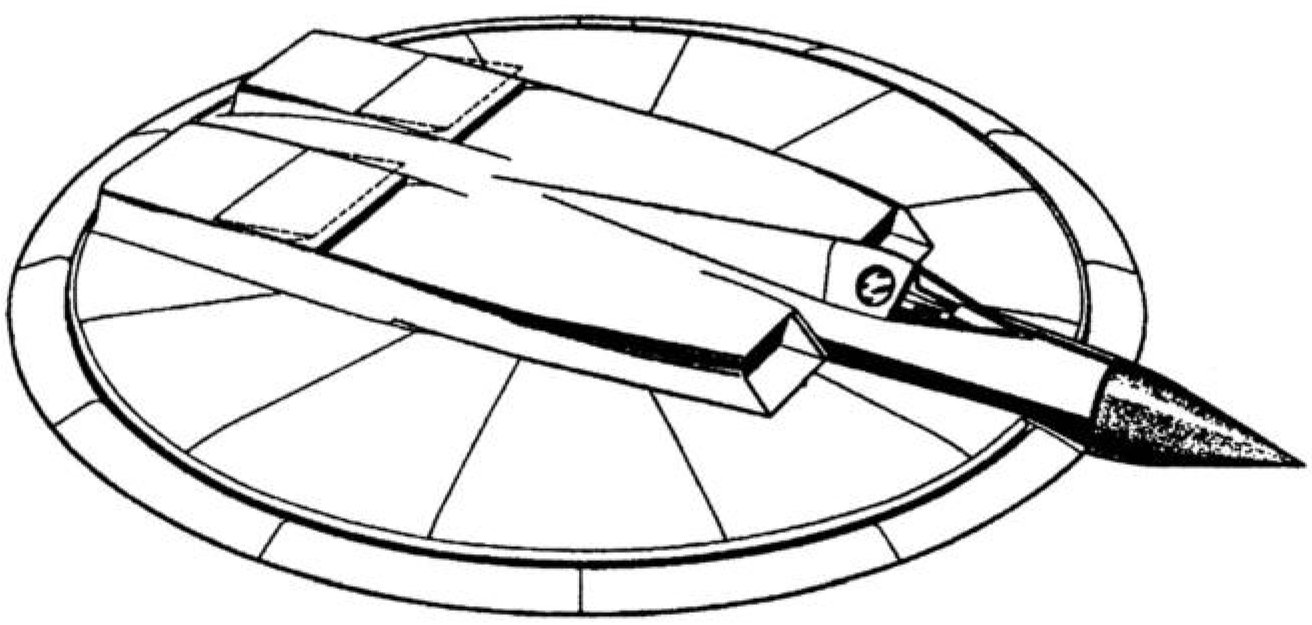
To intentionally mislead outsiders, the WS-606A designation was also used for the Avrocar project, which emerged at the beginning of 1958. This evidently generated problems with USAF personnel who seem to have been very confused by the continuing use of Project 1794, mixed with WS-606A and Avrocar. More than one recently released document shows requests for clarification on designations. Eventually this seems to have been resolved by referring to WS-606A as the supersonic application, while simply using the name Avrocar for the later project.

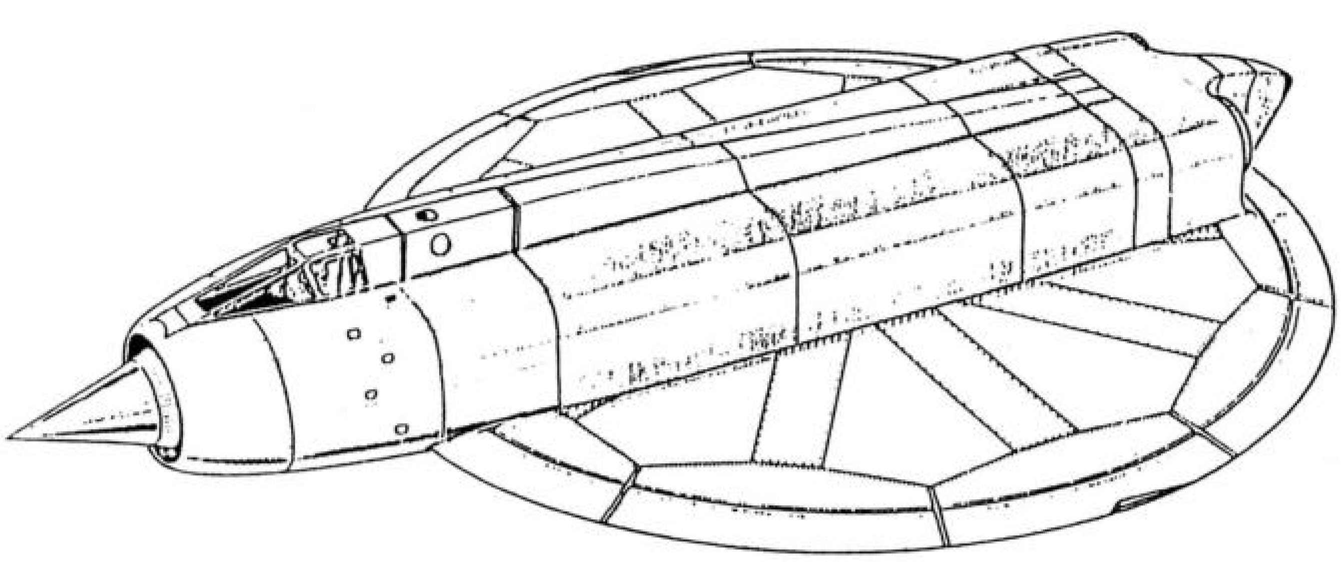
In January 1958, Avro informed the USAF that they had built a full-scale version of WS-606A minus the outer wings, although this may have been (more or less) the six-engined test rig used for the MX 1794 flying disc. By the following month discussion of funding had been raised with the USAF who were advised that one complete supersonic WS-606A would cost three times that of two smaller Avrocars. By March 1958, a 1/12th-scale model of the supersonic WS-606A had been completed and shipped to MIT in Boston where wind tunnel testing was being

Avro Canada WS-606A six-engine configuration. USAF









Left and below left: **Avro Canada WS-606A four-engine configuration.** USAF

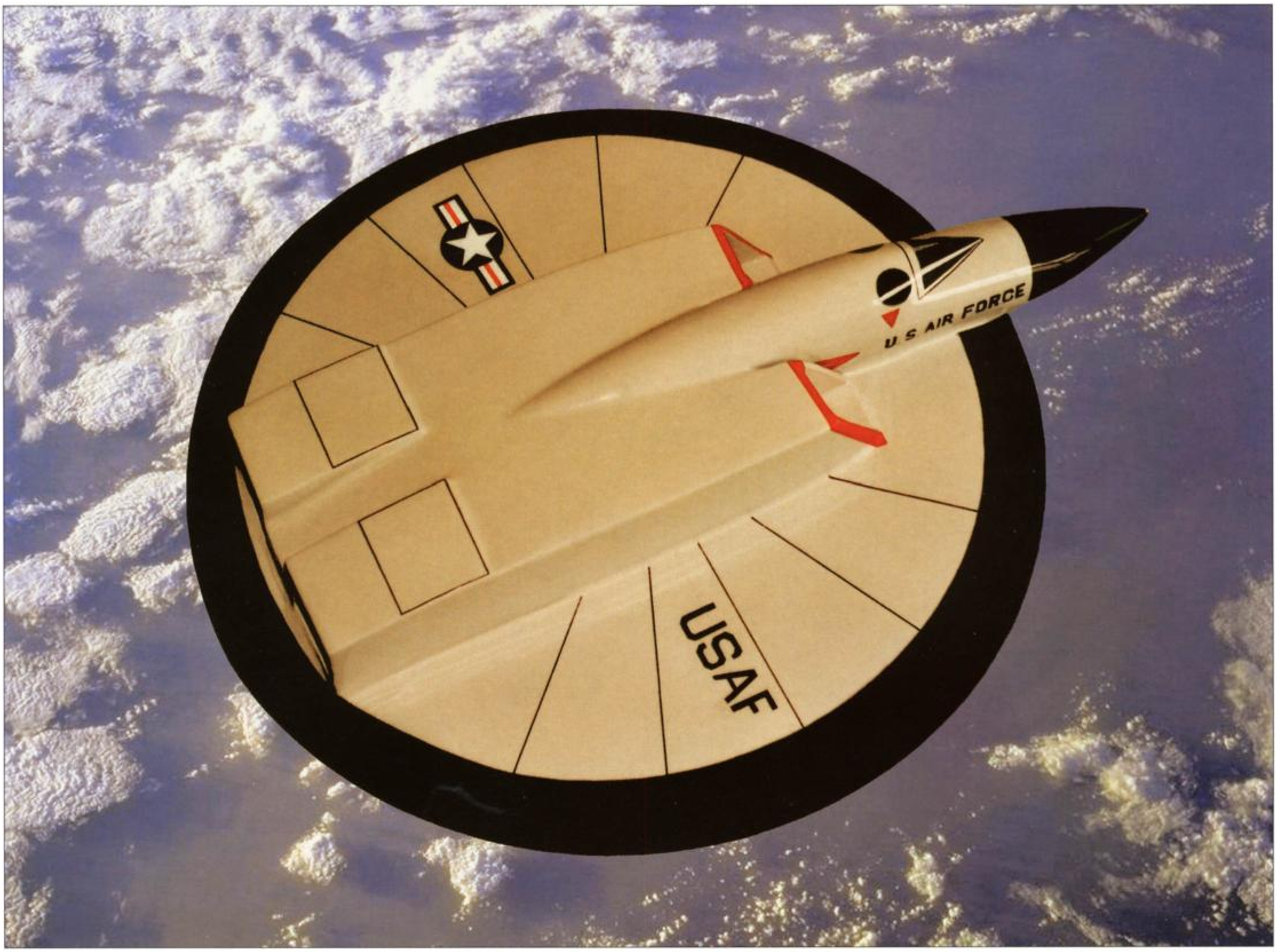
Bottom left: **Avro Canada WS-606A two-engine configuration.** USAF

conducted. Then the programme seems to have faltered, with disagreements taking place between the USAF and Avro concerning a number of technical issues.

Finally, on 22nd March 1958 Joseph Ellis, who headed the Design Branch of the USAF's Aircraft Laboratory, recommended that all work on the supersonic WS-606A project should be halted. On 20th February 1959 Avro employees were laid off following the highly controversial cancellation of the CF-105 Arrow, but three days later all members of Avro's SPG were reinstated. Work resumed on Avrocar and the supersonic WS-606A aircraft, with detailed research being carried out to resolve wing flutter and sonic fatigue problems. Estimates made in June 1959 by the USAF suggested that the cost of fully developing WS-606A would reach $50 million by the mid-1960s when the aircraft was expected to enter production. Wind tunnel testing continued in America, with hundreds of hours being accumulated, and WS-606A was still a candidate for use by the USAF and the RCAF until the middle of 1960, when it was formally cancelled.

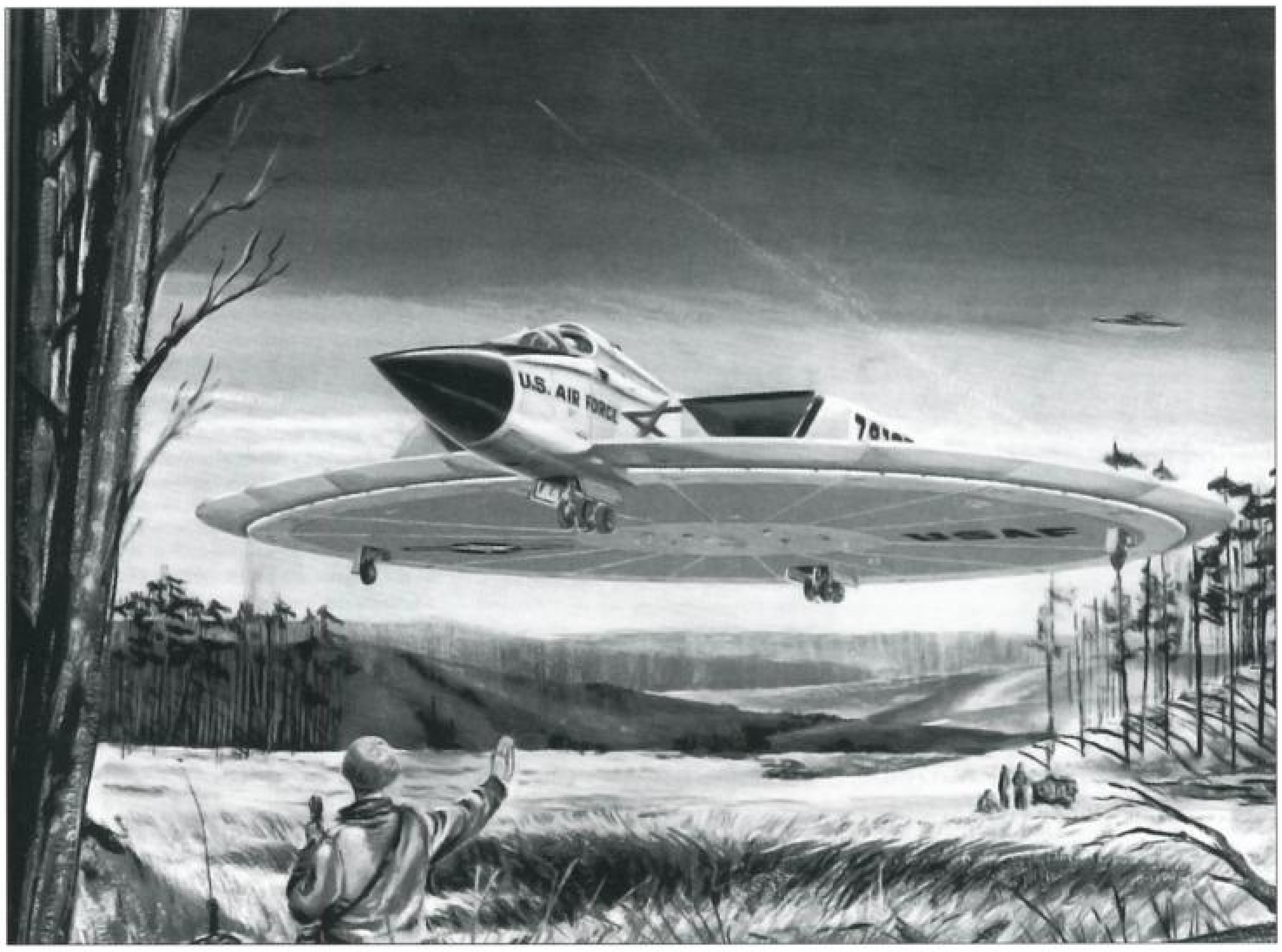
In the final analysis, the ill-fated but highly advanced CF-105 Arrow would have been a far superior military aircraft to the WS-606A Supersonic Application and, although it was larger and lacked a VTOL capability, there was plenty of potential for further development. Avro talked about developing the Arrow into a Mach 3 interceptor capable of reaching 100,000ft (30,000m) and into a long-range photo-reconnaissance aircraft. The Canadian government jointly funded WS-606A with the USAF and millions of dollars were spent on its development, with little or nothing to show at the end of the day.

Running in parallel and controlled by the same USAF group was another potential U-2 replacement known as the CL-400 Suntan. Secretly developed by Lockheed's Skunk Works under the direction of Kelly Johnson, this big hydrogen-fuelled aircraft also proved to be a costly technological step too far and finally met with cancellation. In 1959 the Mach 3+ Lockheed A-12 Blackbird was selected as the follow-on spyplane to the U-2, pushing the Mach 6 Convair Kingfish out of the way. Perhaps rather surprisingly, all USAF Blackbirds are now in museums, while later versions of the U-2 remain in service! Precise histories of the supersonic WS-606A and



Avro Canada WS-606A four-engine configuration. Flight simulation. Allyson Vought/Bill Rose

Avro Canada WS-606A vertical landing at improvised site. USAF



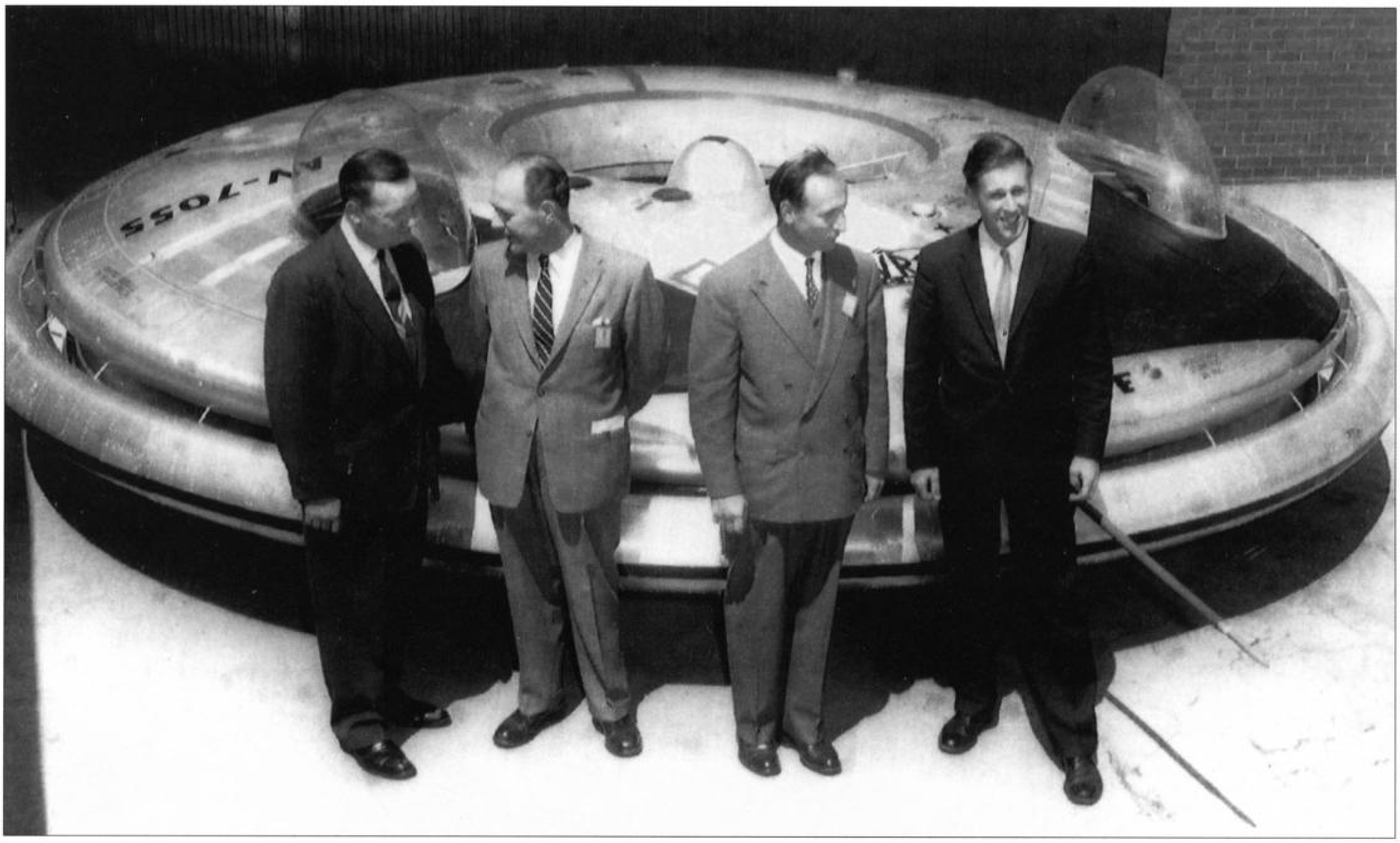
CL-400 Suntan remain classified for reasons that are not totally clear, but it seems likely that these costly dead-end black projects remain sources of lingering embarrassment.

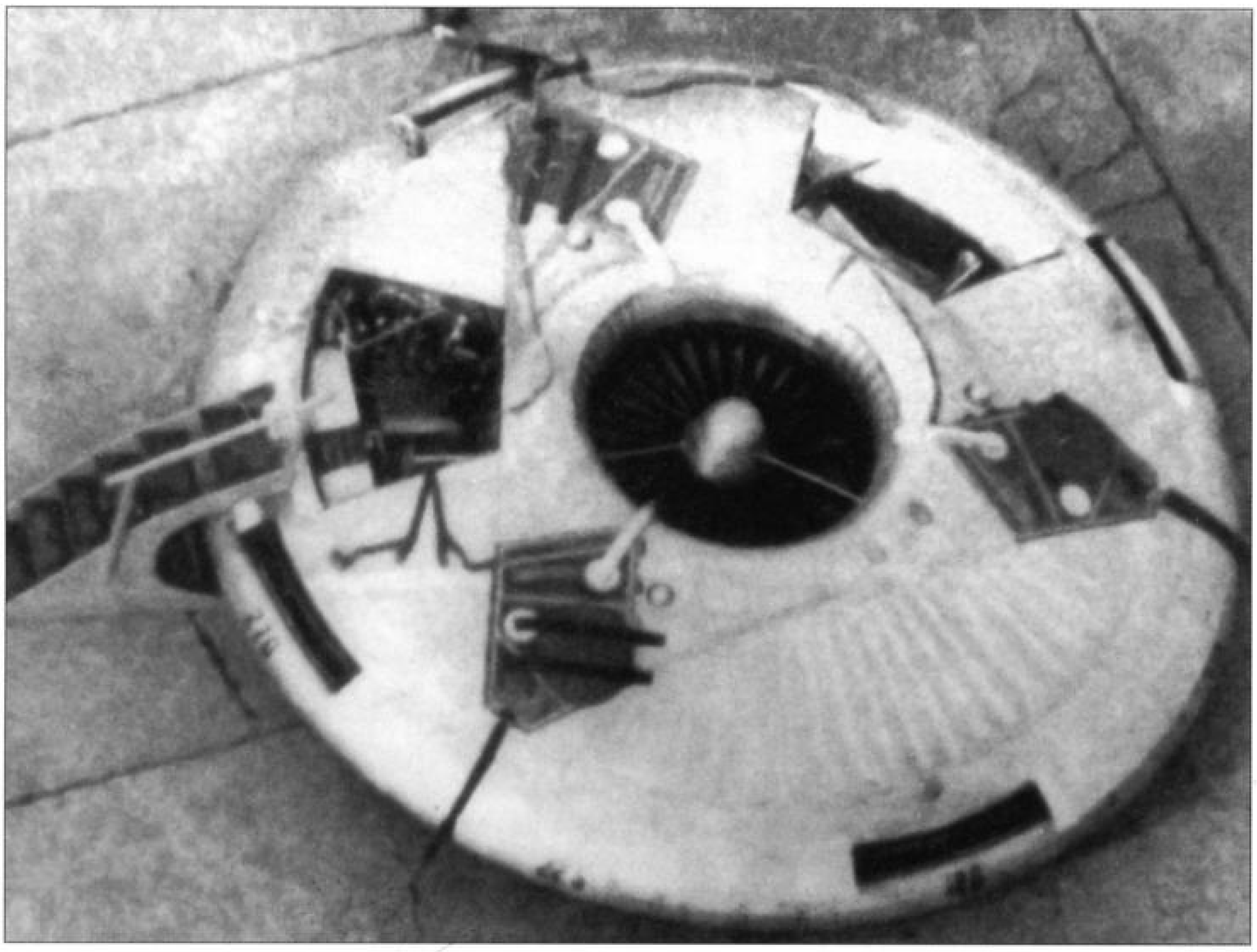
Avrocar

Press speculation about a top secret Avro Canada project, believed to be called VZ-9, continued throughout 1958.

Two prototypes were completed and the first vehicle was eventually shipped to NASA-Ames for wind tunnel testing.

In 1960 a poor quality aerial photograph of a disc-shaped craft was conveniently made available to the press. A delegation of media representatives were then invited to view the second completed VZ-9AV saucer, which was being publicly called The Avrocar.





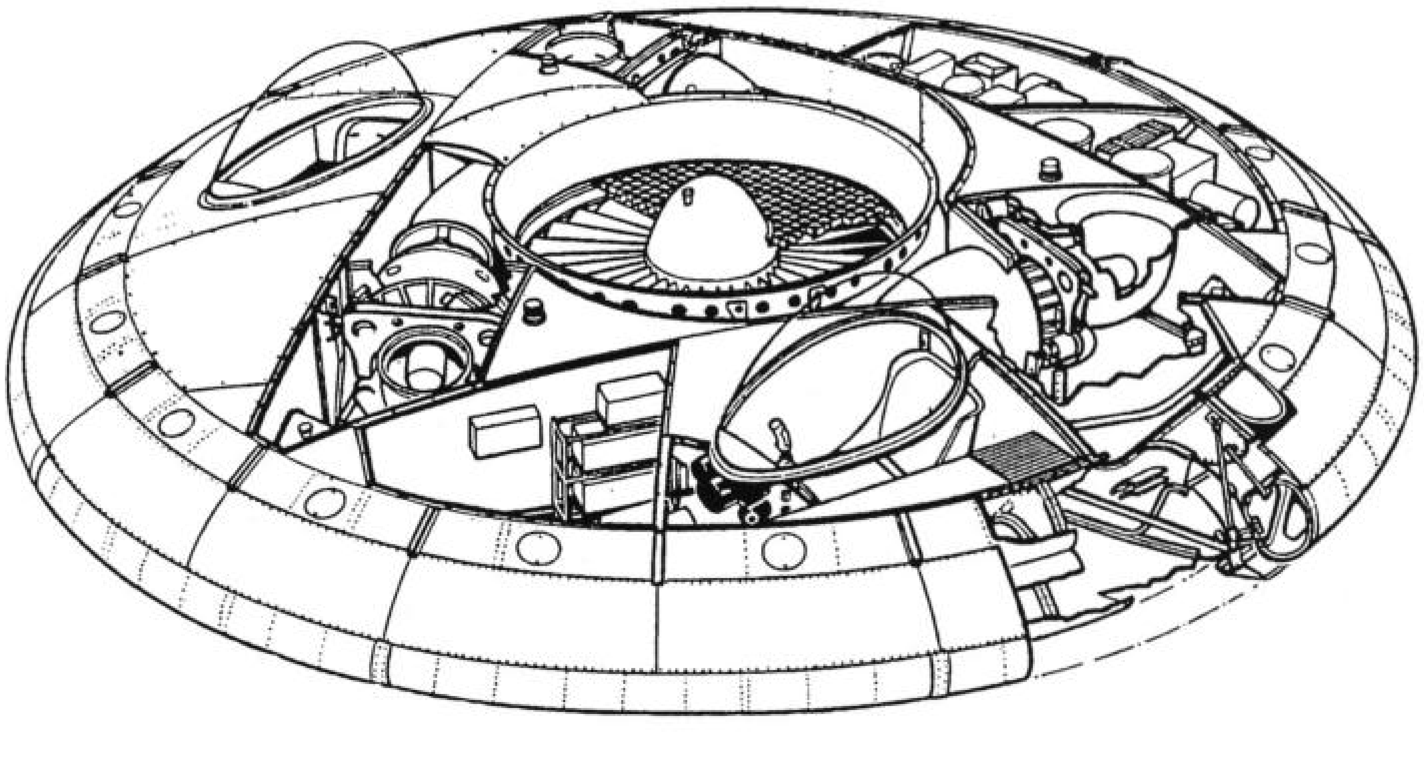
Members of the Avro Canada Special Projects Group by Avrocar. Avro Canada

An early overhead view of Avrocar. Avro Canada

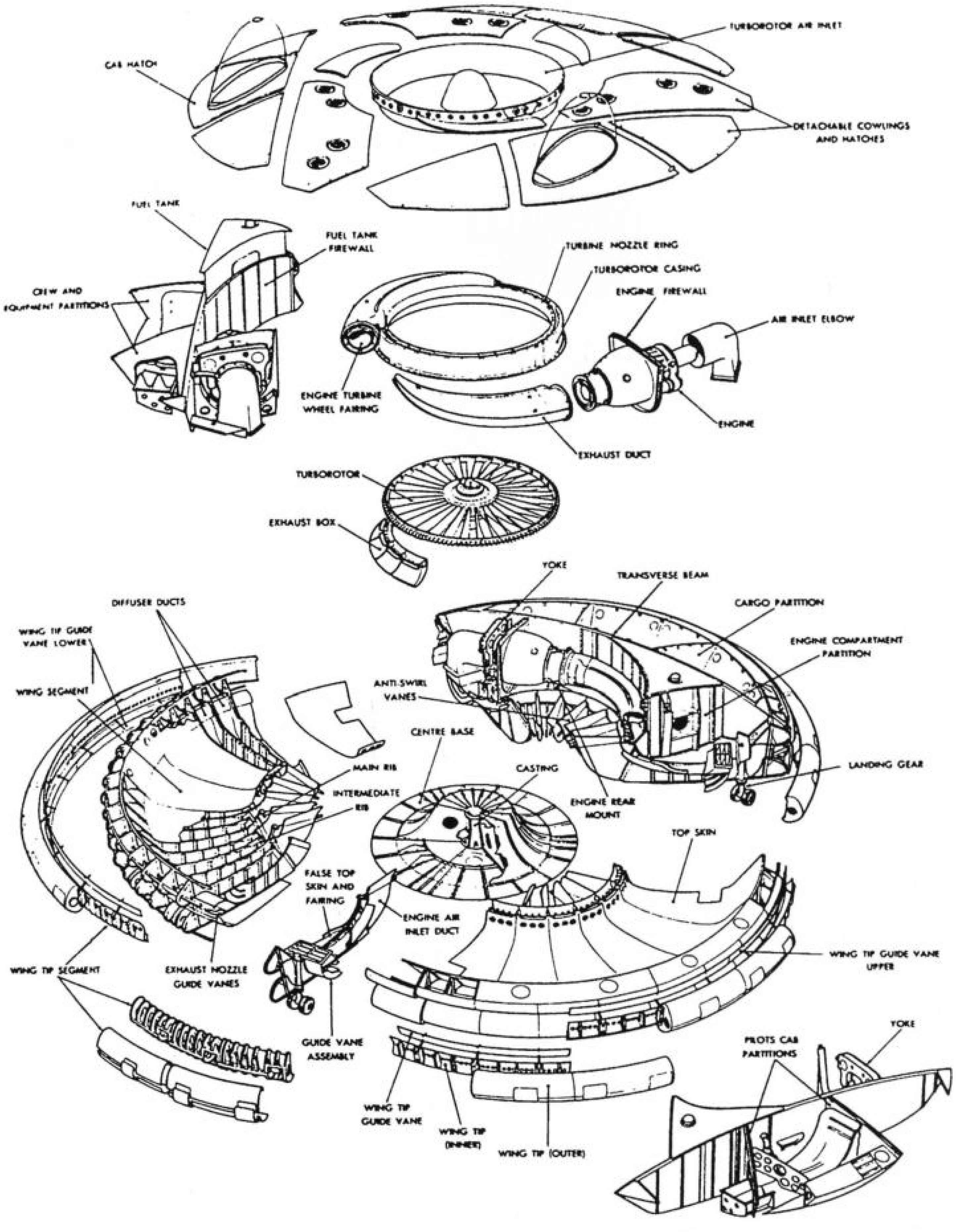
The VZ-9AV Avrocar had been under development for two years and many of its features were adapted from earlier discplane engineering studies. The USAF's original WS-606A Avrocar project had now given way to a new concept for the US Army (hence the VZ-9AV designation), although the USAF continued to handle the development programme. The small Avrocar was 18ft (5.49m) in diameter, 3ft (0.91m) high and it weighed 5,650 lb (2,562kg). Three symmetrically disposed Continental J-69 turbojets with individual ratings of 927 lb (4.12kN) static thrust were used to drive a centrally located 5ft (1.52m) diameter fan by means of their exhaust.

Most of this exhaust gas was then directed through chambers to nozzles around the periphery of the craft to provide lift and motion. The 2,780rpm rotor spin was also expected to provide a degree of gyroscopic stabilisation and dampen pitch and roll motions. Provision was made for two crewmembers and range was initially calculated at 100 miles (160km) with a 2,000 lb (907kg) payload stored in the rear bay.

The US Army had been sold the idea of a compact air-jeep, which could hover like a helicopter and reach 300mph (482km/h) at 10,000ft (3,048m), but Avrocar never even came close to fulfilling this expectation. In fact the VZ-9AV Avrocar tested at Malton proved to be nothing more than an incredibly noisy hovercraft which performed badly during tethered and free flight trials. Nevertheless, it is hard to believe that John Frost and T Desmond Earl didn't realise there were serious deficiencies with this design long before



Cutaway drawing of the Avrocar. USAF


CAB HATCH
TURBOROTOR AIR INLET
DETACHABLE COWLINGS AND HATCHES
FUEL TANK
FUEL TANK FIREWALL
CREW AND EQUIPMENT PARTITIONS
TURBINE NOZZLE RING
TURBOROTOR CASING
ENGINE FIREWALL
AIR INLET ELBOW
ENGINE TURBINE WHEEL FAIRING
ENGINE
EXHAUST DUCT
TURBOROTOR
EXHAUST BOX
YOKE
TRANSVERSE BEAM
CARGO PARTITION
ENGINE COMPARTMENT PARTITION
DIFFUSER DUCTS
WING TIP GUIDE VANE LOWER
WING SEGMENT
ANTI-SWIRL VANES
CENTRE BASE
CASTING
LANDING GEAR
MAIN RIB
INTERMEDIATE RIB
ENGINE REAR MOUNT
TOP SKIN
FALSE TOP SKIN AND FAIRING
ENGINE AIR INLET DUCT
WING TIP SEGMENT
EXHAUST NOZZLE GUIDE VANES
WING TIP GUIDE VANE UPPER
GUIDE VANE ASSEMBLY
YOKE
PILOTS CAB PARTITIONS
WING TIP GUIDE VANE
WING TIP (INNER)
WING TIP (OUTER)

Main components forming the Avrocar. USAF

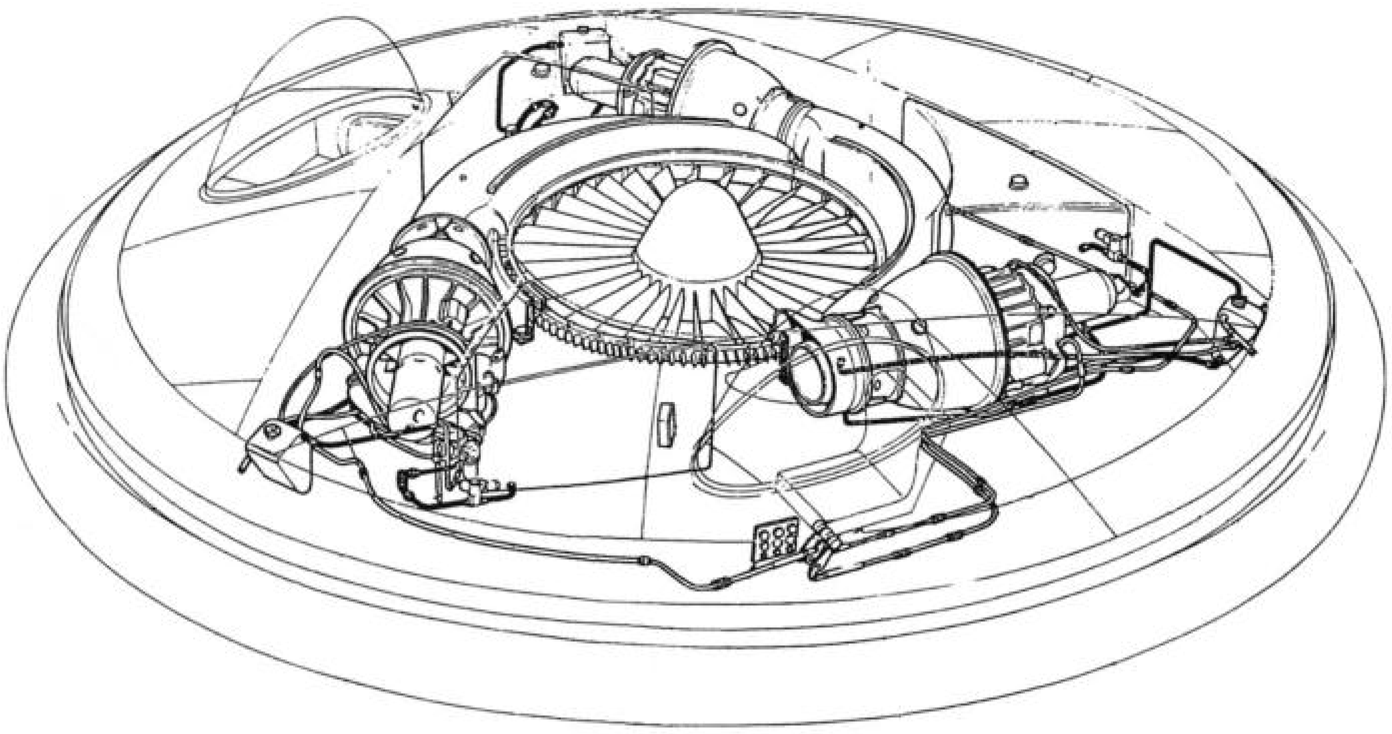
the first public showing. They must have known that Avrocar was incapable of functioning properly and papers released by the Wright Research and Development Center in 1990 reveal many serious problems with the design.

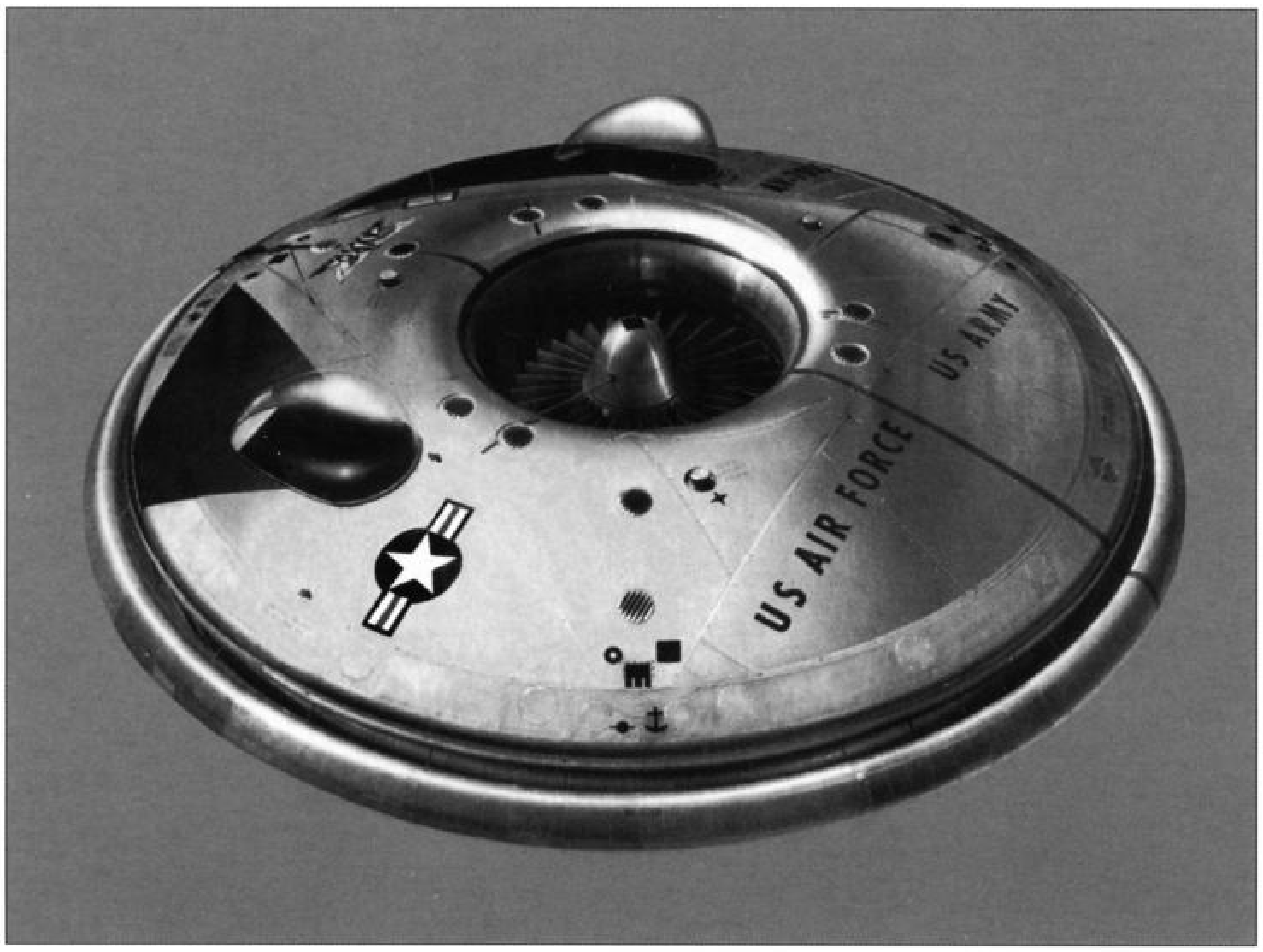
Primarily, these were unacceptable turbine inlet temperatures, which prevented the J-69 engines from achieving full power. This meant that the fan never reached the required speed and there was insufficient airflow to meet performance requirements. A long list of associated problems followed and, perhaps most significantly, Avrocar proved very difficult to control in flight. The Avrocar tested at Malton can be found at the US Army Transportation Museum, Fort Eustis, Virginia. The other vehicle tested by NASA was eventually sent to the National Air & Space Museum and it currently resides in the Paul E Garber Storage and Restoration Facility at Silver Hills, Maryland.

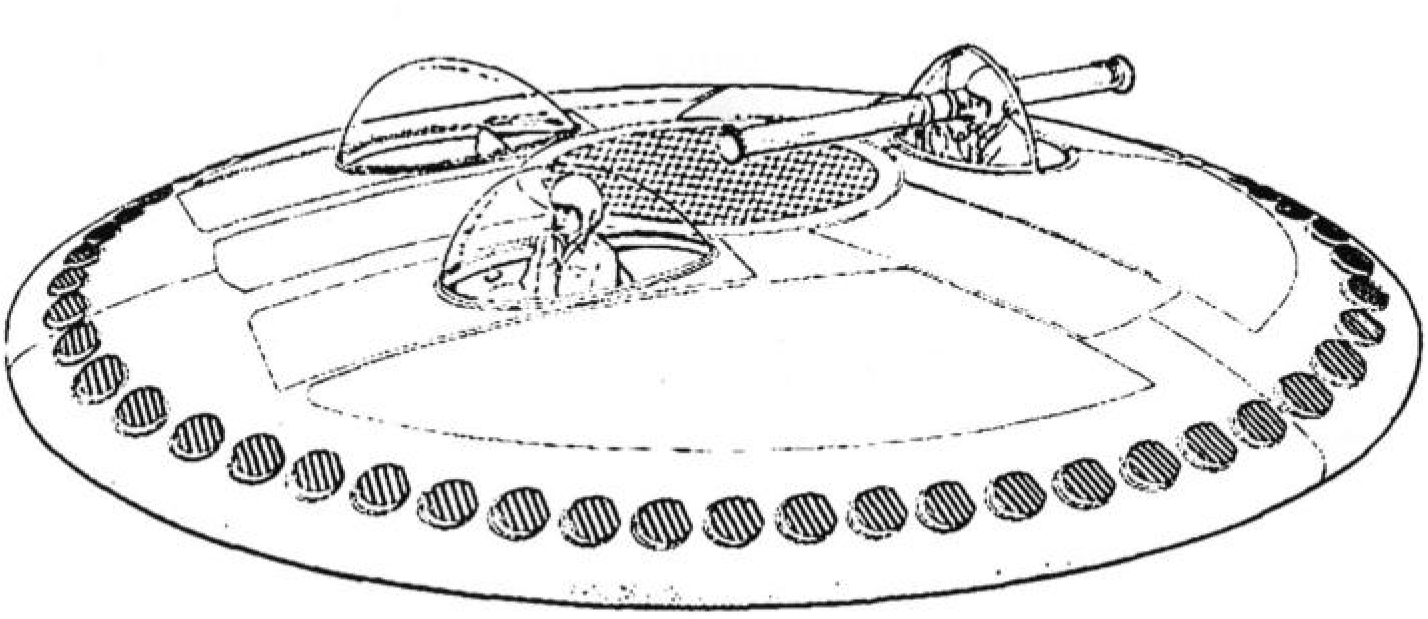
Documents suggest a third Avrocar was completed at Malton. Nothing is currently known about this vehicle, although it probably ended up as scrap. Several former Avro engineers have stated that Avrocar would have functioned as originally planned if sufficient money had been provided for full development.

Frost completed design studies for a more advanced Avrocar, powered by two General Electric J-85 engines driving a 6ft (1.83m) diameter fan, with some central exhaust ducting for improved performance. Several variants were proposed and the first Mk 2 Avrocar featured a single tail fin and a side-by-side forward cockpit. The second concept was broadly similar but utilised short swept wings with stabilising fins at the tips. Both proposals retained the same 18ft (5.49m) diameter body size and four short hydraulically dampened landing legs were fitted. A number of other Avrocar variants were studied and these included a series of commercial Avromobile concepts, a small remotely controlled surveillance craft called Avrodrone and a naval anti-submarine vehicle called Avropelican, which both looked rather like the later Sikorsky Cypher.

During June 1961 USAF involvement with Avro Canada ceased and by December of that year the programme was formally terminated. Avro Canada's fate had already been sealed by the politically motivated cancellation of the CF-105 Arrow and the best remain-







A schematic showing the Avrocar's propulsive system. USAF

Avrocar in USAF markings. USAF

Avrojeep concept. USAF

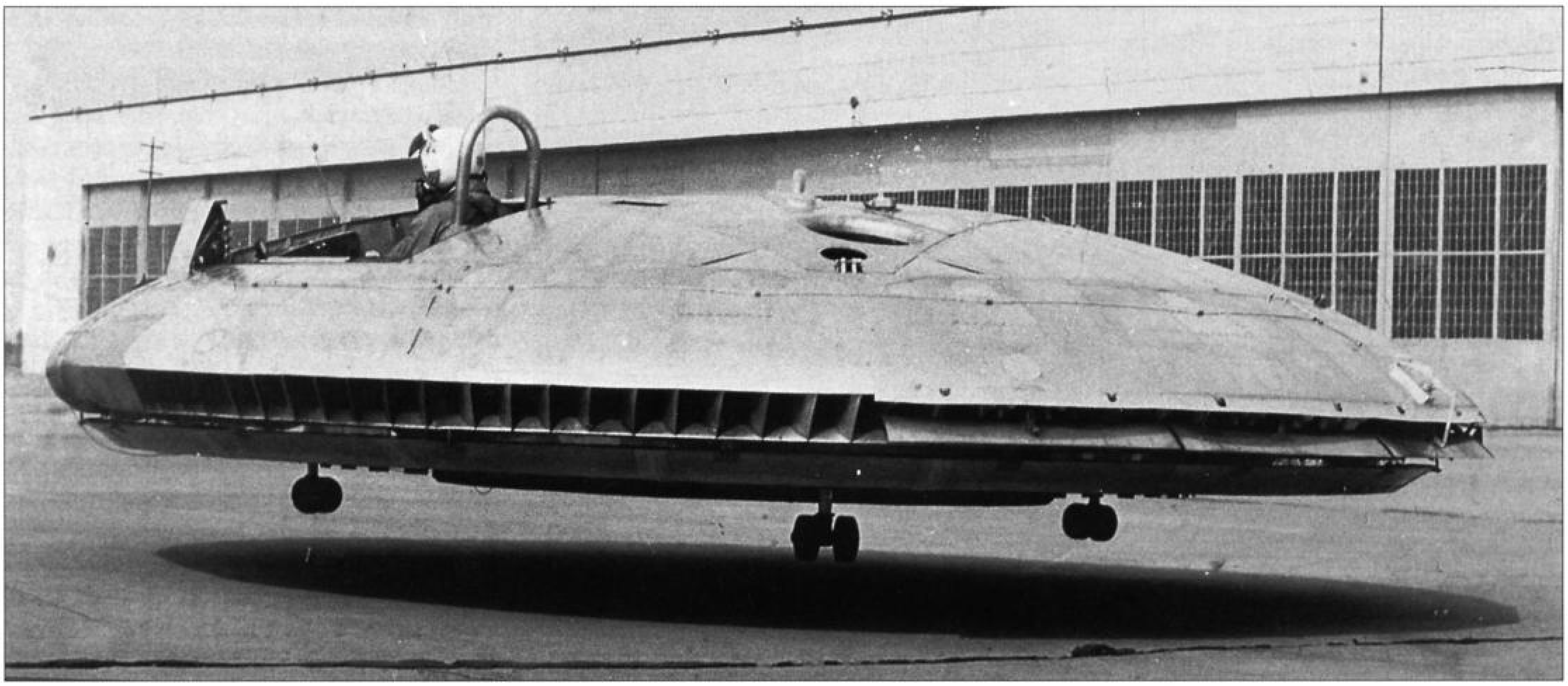
ing staff were recruited by American contractors and NASA. In early 1962 the plant at Malton was closed down and the site sold to Douglas Aircraft of Canada. Today the Malton factory has virtually disappeared beneath an industrial area attached to Toronto Airport and only a couple of small buildings remain.

The outstanding question is whether any of the high-performance Avro flying discs were secretly constructed and test flown. It is a documented fact that the USAF issued an order to proceed with the development of Silver Bug on 29th December 1954 and official records show that the British expected the small Silver Bug research aircraft to be completed during 1955. A USAF press release (No 1053-55 dated October 1955) discusses the imminent test flight of a new VTOL prototype, which might have been the Silver Bug research aircraft or the Ryan X-13 tail-sitter research prototype.

By 1955 Silver Bug had evolved into Project 1794 and by early 1956, Avro Canada had completed a turbo-ramjet engine test rig, which constituted about three-quarters of the aircraft. According to USAF document 57WCLS-2497, a delegation of senior USAF officials visited Avro Canada on 26th March 1957 and was shown, 'facilities being used to manufacture the (1794) prototype aircraft'. The report goes on to say that, 'this (tour) included an inspection of various (1794) components which have already been produced'.

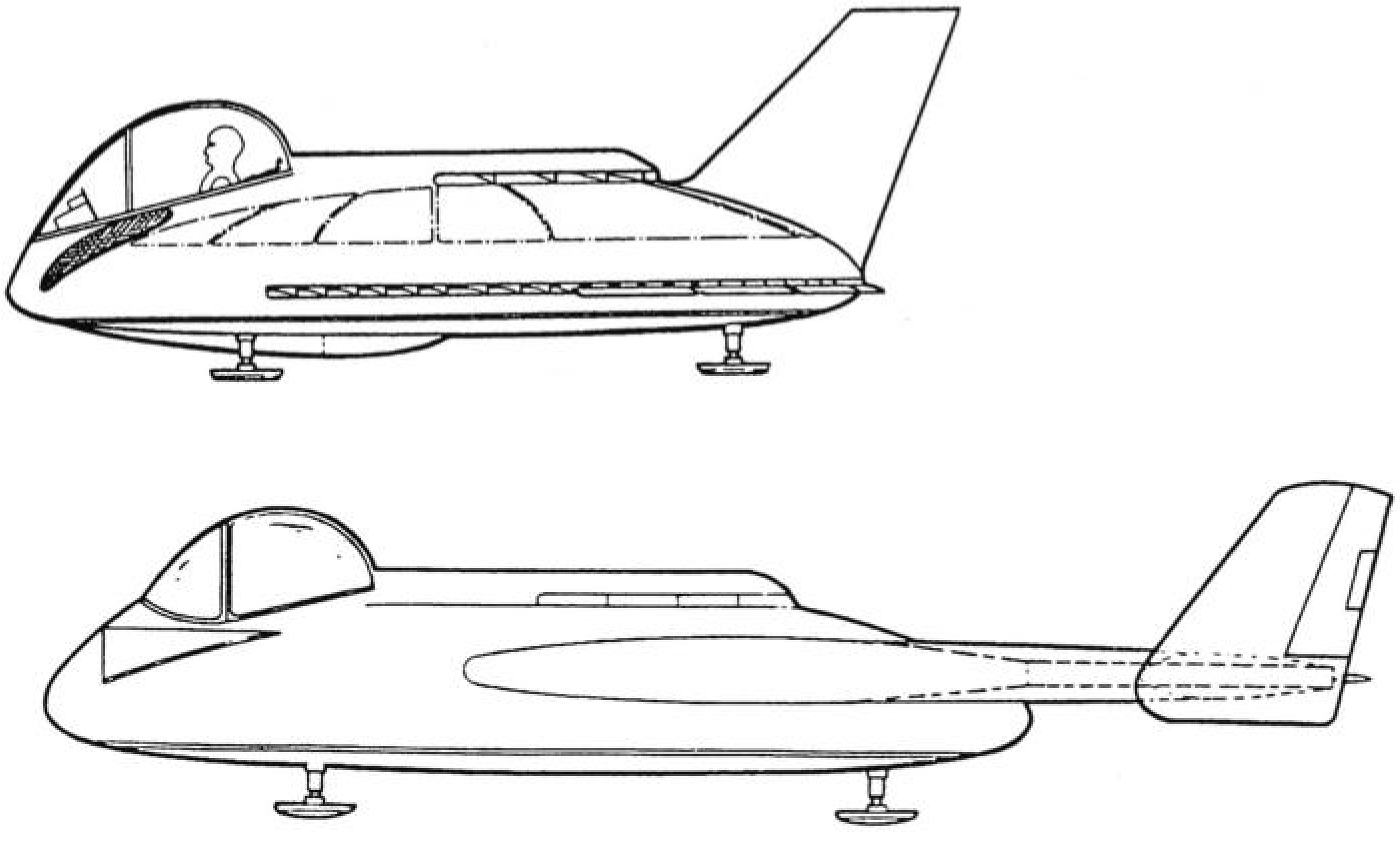
Part of another previously secret (but incomplete) set of USAF documents from 1957 (with the reference 57RDZ-3107), has the following to say: 'The design of the basic structure and propulsion unit (of 1794) is substantially complete and it is expected that the additional items together with all preliminary modifications to the rig design required by the prototype will be complete by June 1957'. The same document also discusses a tethered test stage and tethering rig for preliminary flight trials, 'probably consisting mainly of a large crane'.

In his 2001 book *Canada's Flying Saucer*, author Bill Zuk describes how the turbo-ramjet engine developed for the MX 1794 and WS-606A was tested at Malton. According to Zuk a very serious situation arose when one of the six Vipers ran wild during a test run. This incident brought the turbo-ramjet trials



Above: **A test flight of the second VZ-9AV Avrocar at Malton in late 1958.** Avro Canada

Right: **Advanced Mk 2 Avrocars.** USAF



Below left: **Advanced Mk 2 Winged Avrocar.** USAF

Below right: **Advanced Mk 2 Avrocar.** USAF

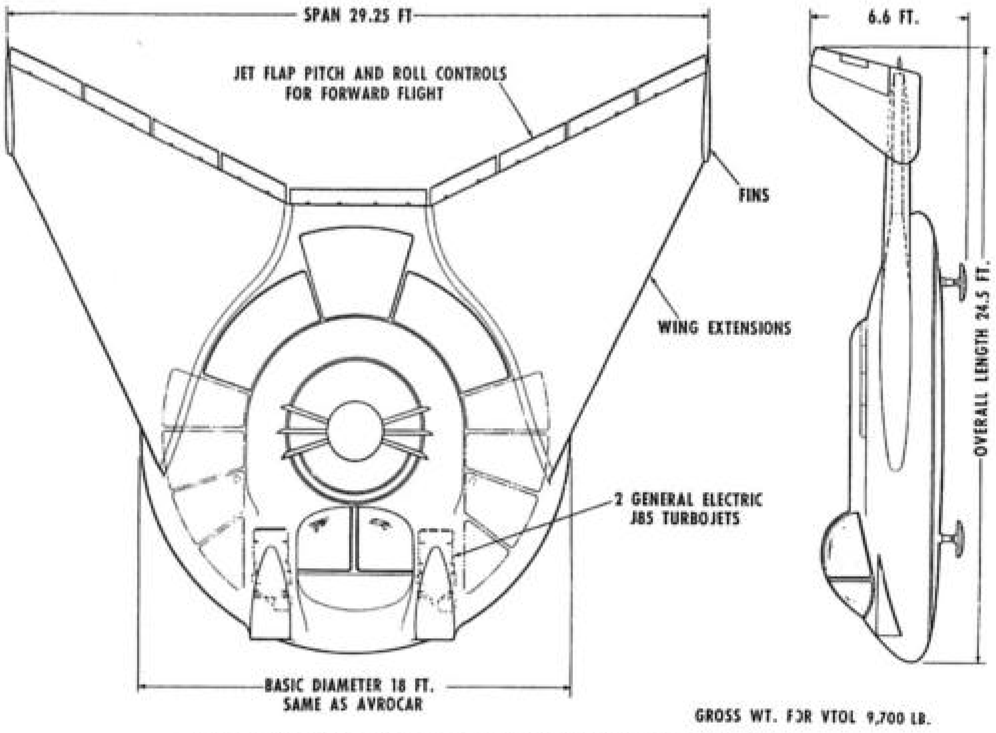

SPAN 29.25 FT
JET FLAP PITCH AND ROLL CONTROLS FOR FORWARD FLIGHT
FINS
WING EXTENSIONS
2 GENERAL ELECTRIC J85 TURBOJETS
BASIC DIAMETER 18 FT. SAME AS AVROCAR
6.6 FT.
OVERALL LENGTH 24.5 FT.
GROSS WT. FOR VTOL 9,700 LB.

FIG 10 AVROCAR DEVELOPMENT VERSION WITH WING EXTENSIONS

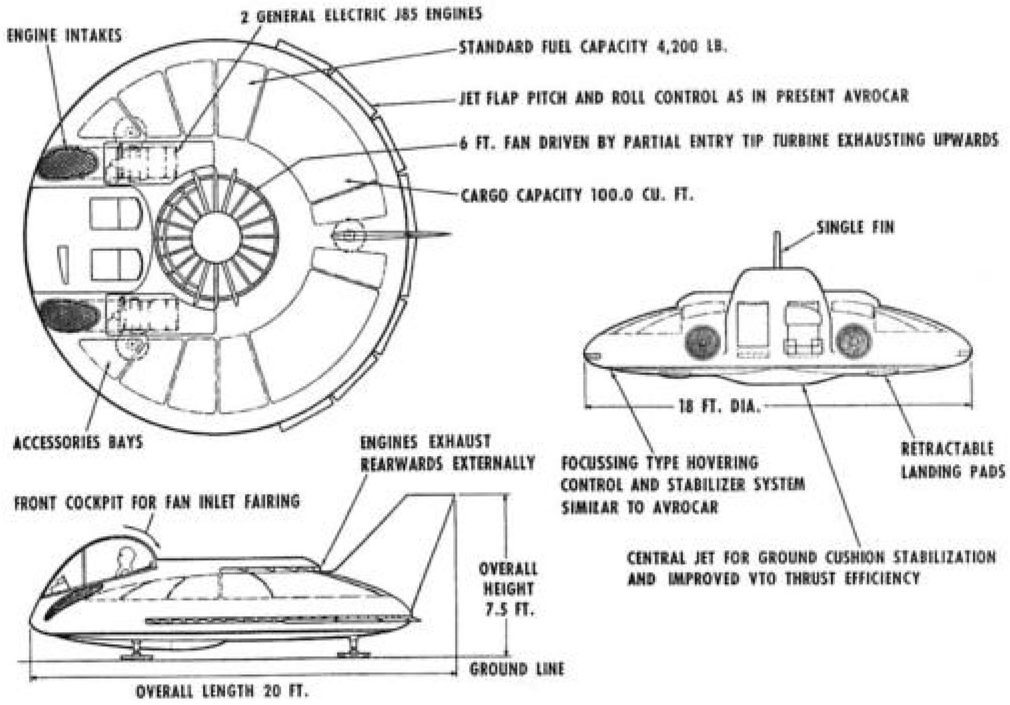
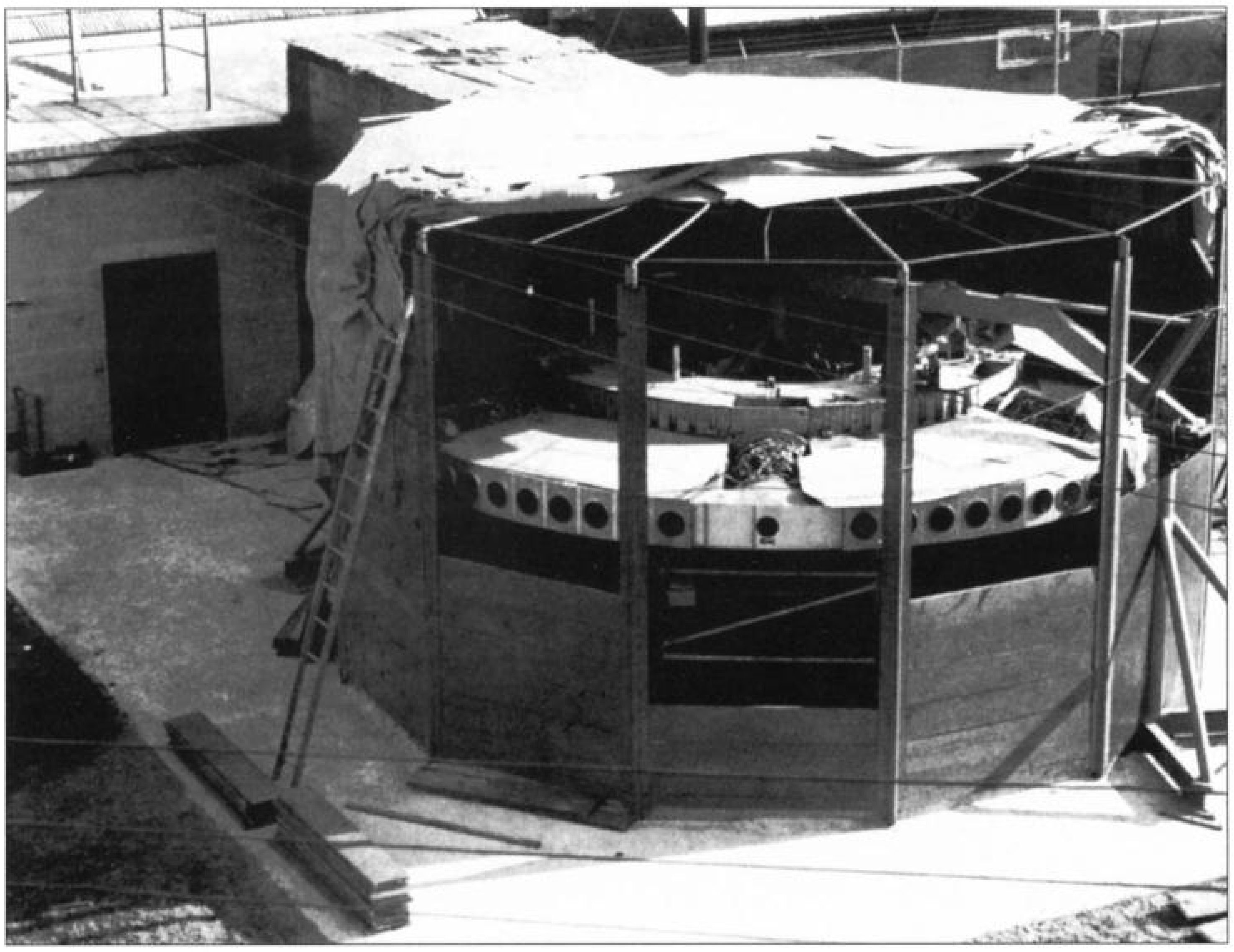

2 GENERAL ELECTRIC J85 ENGINES
ENGINE INTAKES
STANDARD FUEL CAPACITY 4,200 LB.
JET FLAP PITCH AND ROLL CONTROL AS IN PRESENT AVROCAR
6 FT. FAN DRIVEN BY PARTIAL ENTRY TIP TURBINE EXHAUSTING UPWARDS
CARGO CAPACITY 100.0 CU. FT.
SINGLE FIN
ACCESSORIES BAYS
ENGINES EXHAUST REARWARDS EXTERNALLY
18 FT. DIA.
FOCUSSING TYPE HOVERING CONTROL AND STABILIZER SYSTEM SIMILAR TO AVROCAR
RETRACTABLE LANDING PADS
FRONT COCKPIT FOR FAN INLET FAIRING
OVERALL HEIGHT 7.5 FT.
CENTRAL JET FOR GROUND CUSHION STABILIZATION AND IMPROVED VTO THRUST EFFICIENCY
GROUND LINE
OVERALL LENGTH 20 FT.

FIG 9 AVROCAR DEVELOPMENT

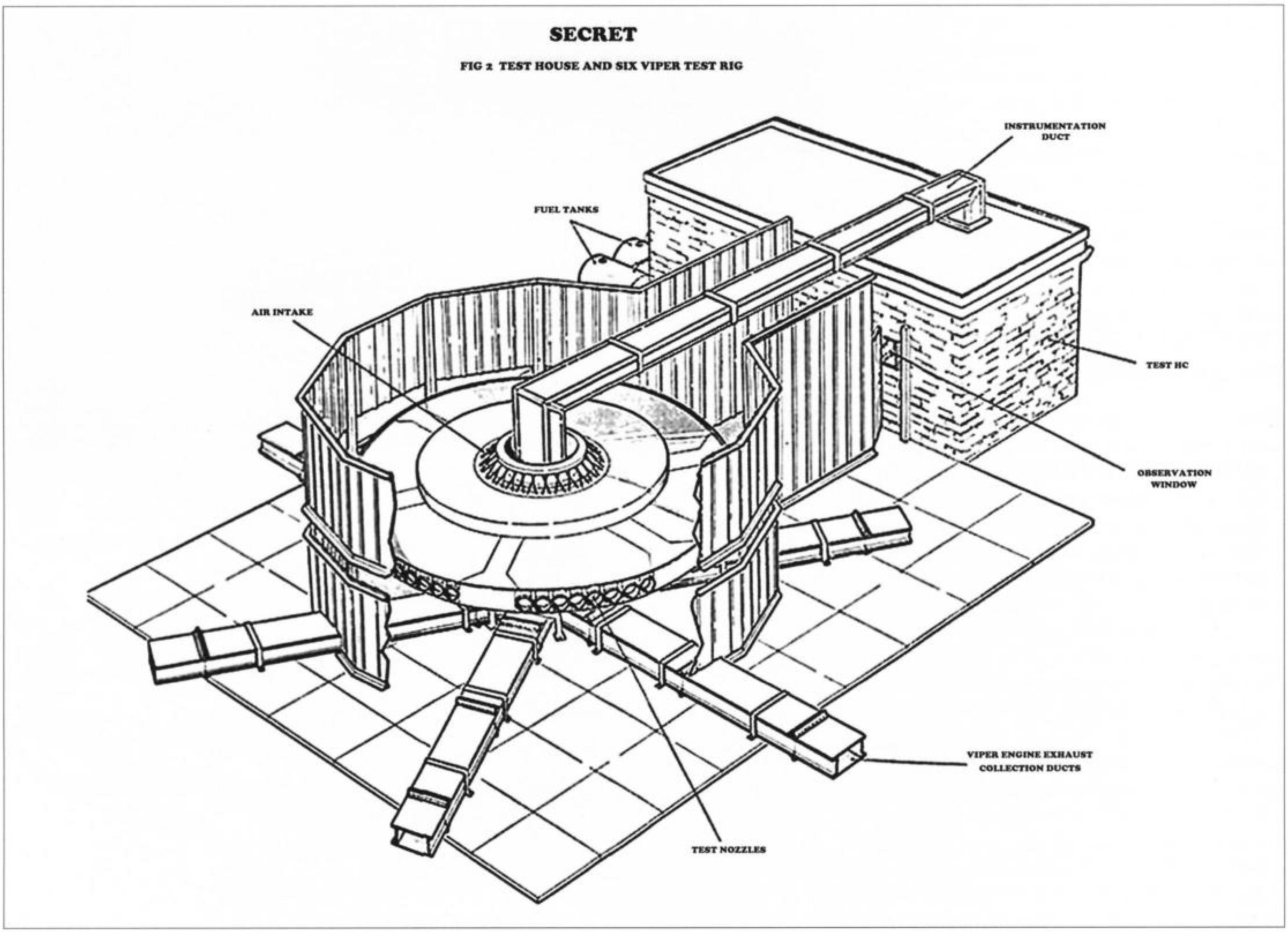


to an abrupt and final halt and may have signalled the end of supersonic development.

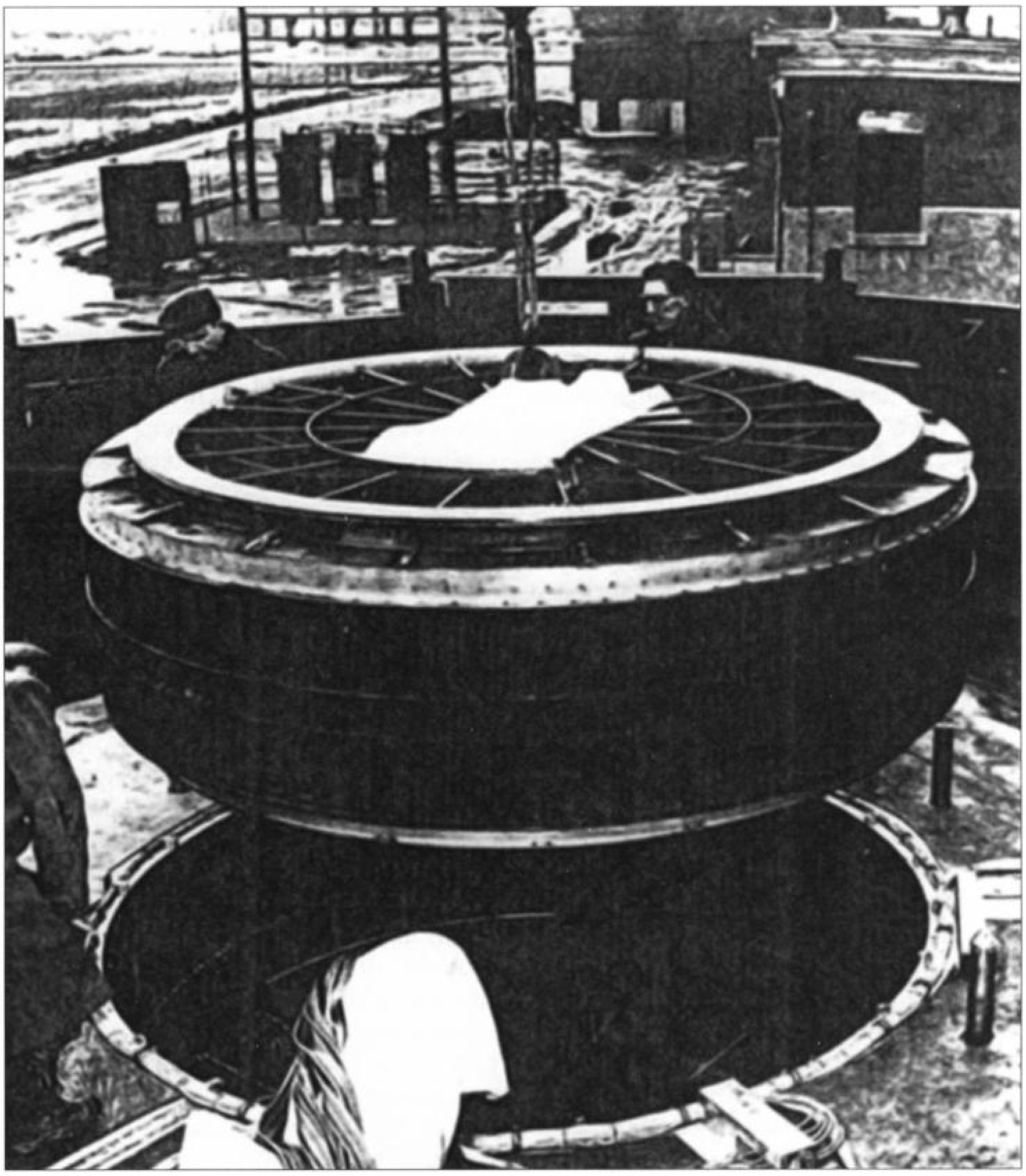
Perhaps Frost's designs were a technological step too far and most engineers agree that the proposals were frighteningly over-complex and contained many features that were untested and might have been prone to failure under operational conditions. However, all the major US contractors were briefed on Avro Canada's flying disc programme and many departments within these companies were working on circular aircraft designs that often progressed to wind tunnel models. Under the direction of Nathan Price, designers based at Lockheed's Skunk Works studied saucer-shaped aircraft throughout the 1950s and the Skunk Works would have been the ideal facility to continue development of Avro Canada's flying discs within a deep black pro-

Left: **The 6-Viper test rig at Avro Canada, Malton, Toronto.** USAF

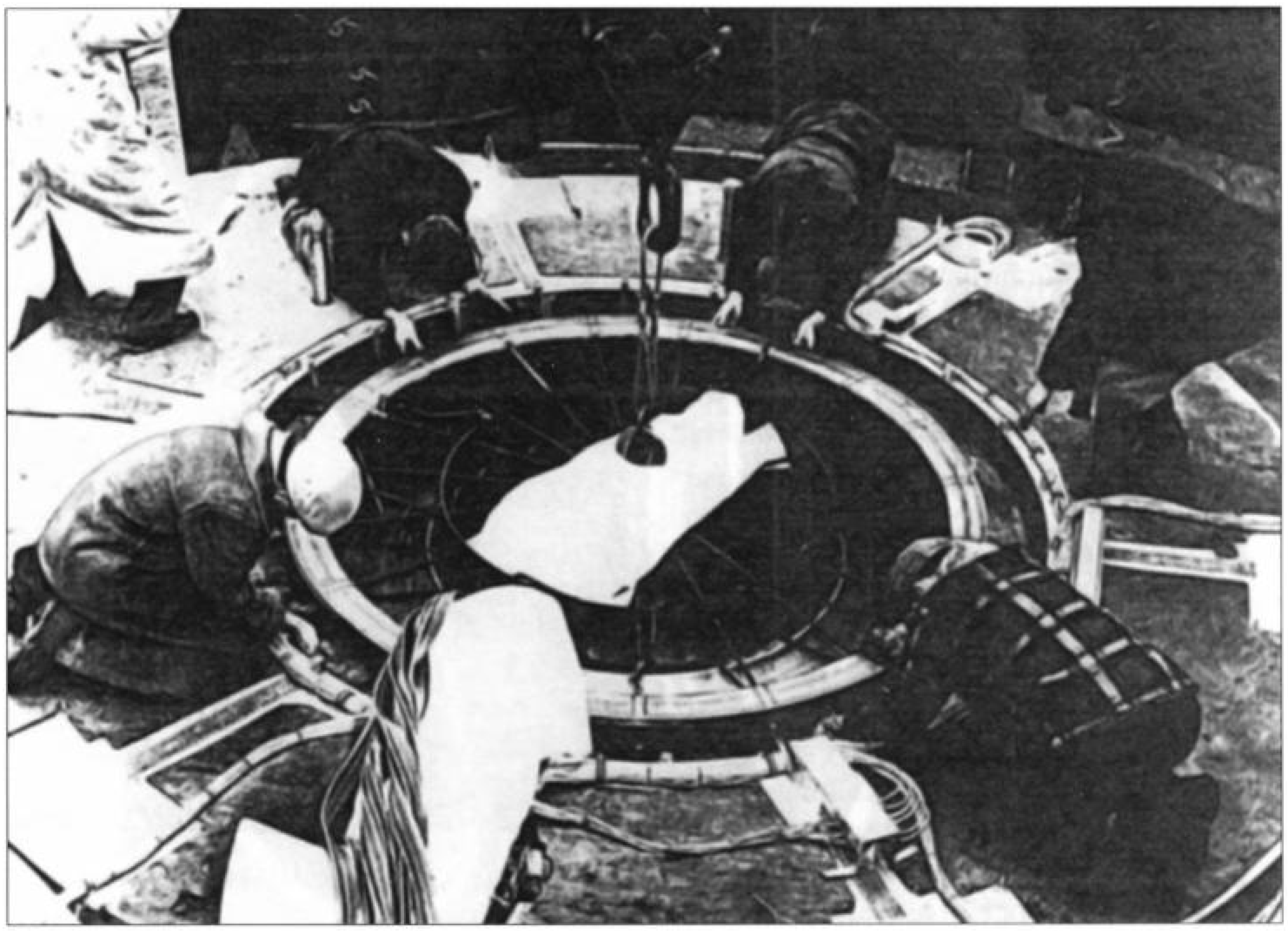
Below: **A schematic of the Avro Canada 6-Viper test rig.** USAF


SECRET
FIG 2 TEST HOUSE AND SIX VIPER TEST RIG
INSTRUMENTATION DUCT
FUEL TANKS
AIR INTAKE
TEST HC
OBSERVATION WINDOW
VIPER ENGINE EXHAUST COLLECTION DUCTS
TEST NOZZLES

Right: **A crane is used to lower the central component of the 6-Viper test rig that was used, assembled and run by the Special Projects Group at Avro Canada, Malton.** USAF



Below right: **Members of the SPG monitor assembly of the 6-Viper test rig as the central component is lowered into place.** USAF



gramme. It also stands to reason that using a foreign contractor like Avro Canada to undertake a top secret USAF aviation project would have caused strong protests from a tough individual like Kelly Johnson, who headed Lockheed's Skunk Works.

Throughout the 1950s there was considerable speculation that Russia undertook a similar programme to Silver Bug and that these aircraft were built, tested and flown across US territories on reconnaissance missions. At the start of Project Y John Frost believed this to be a distinct possibility and similar fears within the Pentagon may have encouraged the secret completion of one or two experimental aircraft. With defence contractors enjoying low labour and material costs during the 1950s, it was much easier to convert a new idea into hardware and conceivably a US company like Lockheed might have completed this work, passing these aircraft to the USAF for testing at a location such as Groom Dry Lake, Nevada. Having said that, there is absolutely no supporting evidence and so this remains unlikely, despite numerous UFO reports from the area.

During the development of the Avrocar Frost had discovered the ground cushion effect and this was fully exploited by the British designer Sir Christopher Cockerell, who is widely credited with inventing the Hovercraft. Apparently Frost was far from happy that Cockerell had effectively taken all the glory for his discovery. Disillusioned with the aviation industry, John Frost moved to New Zealand when Avro Canada folded and took up a position with the Airworthiness Section of the Civil Aviation Administration.

Frost briefly returned to Canada in 1964, becoming involved in a boat business in Vancouver. But things didn't work out and he returned to New Zealand, becoming the Technical Services Engineer for Air New Zealand. From then until his retirement in 1978, Frost was responsible for many clever innovations and engineering improvements that included the tail docking system used by Air New Zealand which allowed DC-10 servicing and engine changes. After his retirement, Frost continued to design aircraft and was working on a small man-powered glider when he died on 9th October 1979.

Chapter Four

Postwar Discplane Development

Starting in the late 1940s designers began to take a serious interest in disc-shaped aircraft. Numerous patents were filed, ranging from truly incredible contraptions through to highly engineered concepts produced by top aerodynamicists like John Frost (see the previous chapter). It is impossible to say if this came about as a result of media-driven interest in UFOs, or because of aviation developments during World War Two. However, advanced aerospace research undertaken in Germany had opened the door to a range of interesting possibilities that would have been viewed as Buck Rogers science fiction concepts prior to the Second World War.

Almost every major US aviation contractor took a share of the captured German spoils, which had a significant impact on the development of military aircraft during the following two decades. There have been persistent rumours that German flying disc aircraft fell into American hands, with hardware and documentation being shipped to Wright Field, Ohio for evaluation and study. These possibilities have never been confirmed, nor have the suggestions that Britain obtained an early example of (or detailed plans for) a German Radial Flow Gas Turbine (RFGT), which was developed further and passed to Avro Canada for use in their Project Y flying disc aircraft (Chapter Three).

While there is no proof that any German flying disc technology was transferred to the US (or its allies), there are suspicions that it might have been, and confirmation may exist somewhere within the mountain of classified US documentation that stretches back to the early part of the last century. Aside from this, it is a recorded fact that many senior officials felt that some reliable UFO sightings might involve advanced Soviet aircraft based on captured German technology and that the Russians had somehow leapfrogged an entire generation of military development, achieving a technological lead that could tip the delicate balance of East-West power in their favour. This prompted the Pentagon to urgently seek a VTOL aircraft with the ability to operate from an improvised forward site and possessing superior performance to any next-generation supersonic warplane.

Both the USAF and many of its principal defence contractors studied flying saucer-shaped aircraft throughout the 1950s. Much of this research was classified and, aside from obvious security considerations, there is an enduring belief that special operations have occasionally been hidden behind a veil of UFO mysticism, which has been intentionally maintained over a long period as a useful way to debunk sensitive information leaking into the public domain.

Alfed Loedding and the Flying Saucers

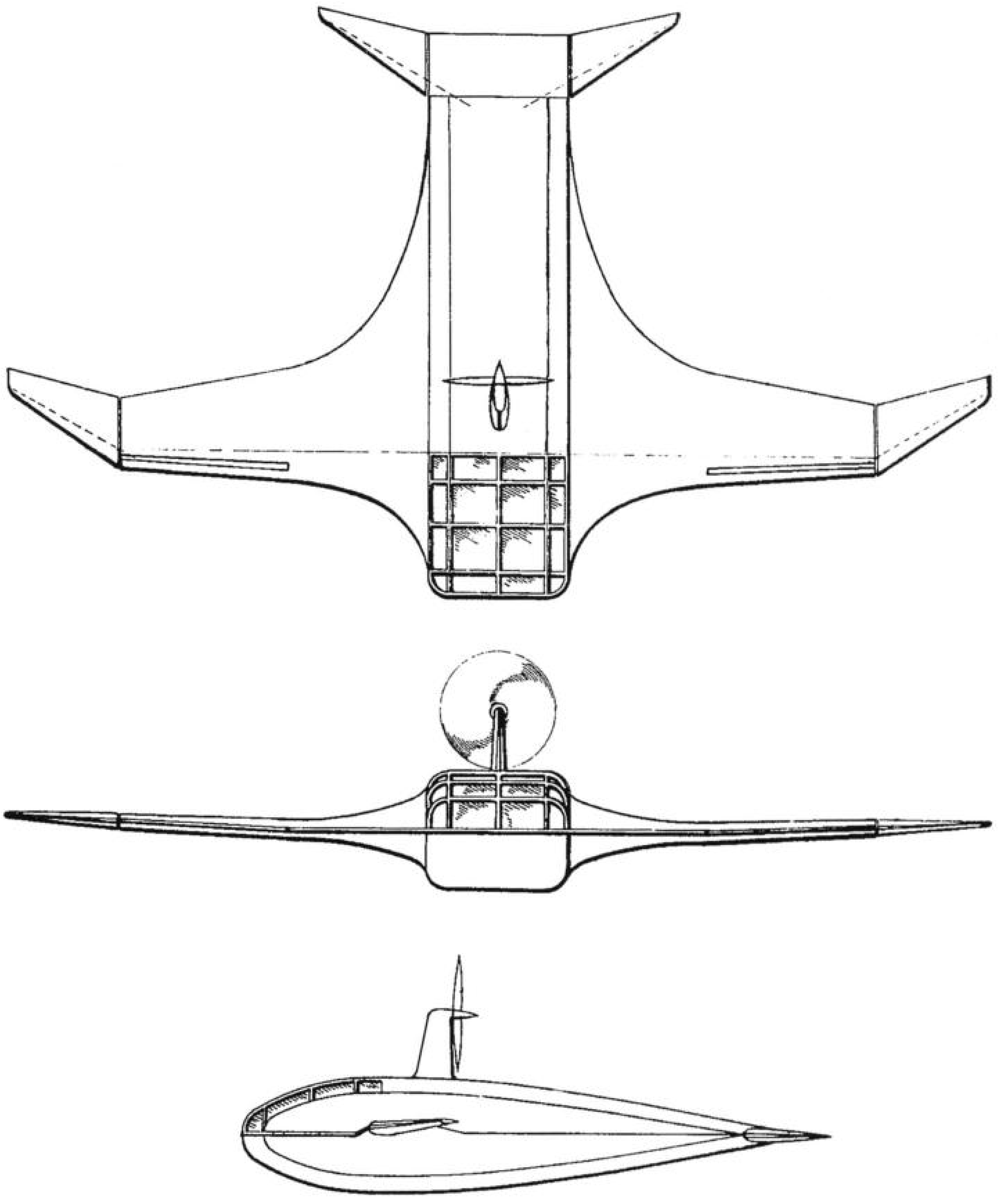
Alfred Christian Loedding remains an intriguing and little-known individual who was involved in all manner of American military (and some civil) aviation research programmes from the 1930s onwards. He held the highest security clearance, worked for USAAF Intelligence, debriefed most of the top wartime German aeronautical scientists, supervised classified projects, acted as the US Air Force's consultant on UFOs and finally worked for NASA. Loedding also designed and patented an extraordinary oval-shaped aircraft with the appearance of a flying saucer.

Alfred Loedding with a model of his discplane at Wright-Patterson AFB. USAF

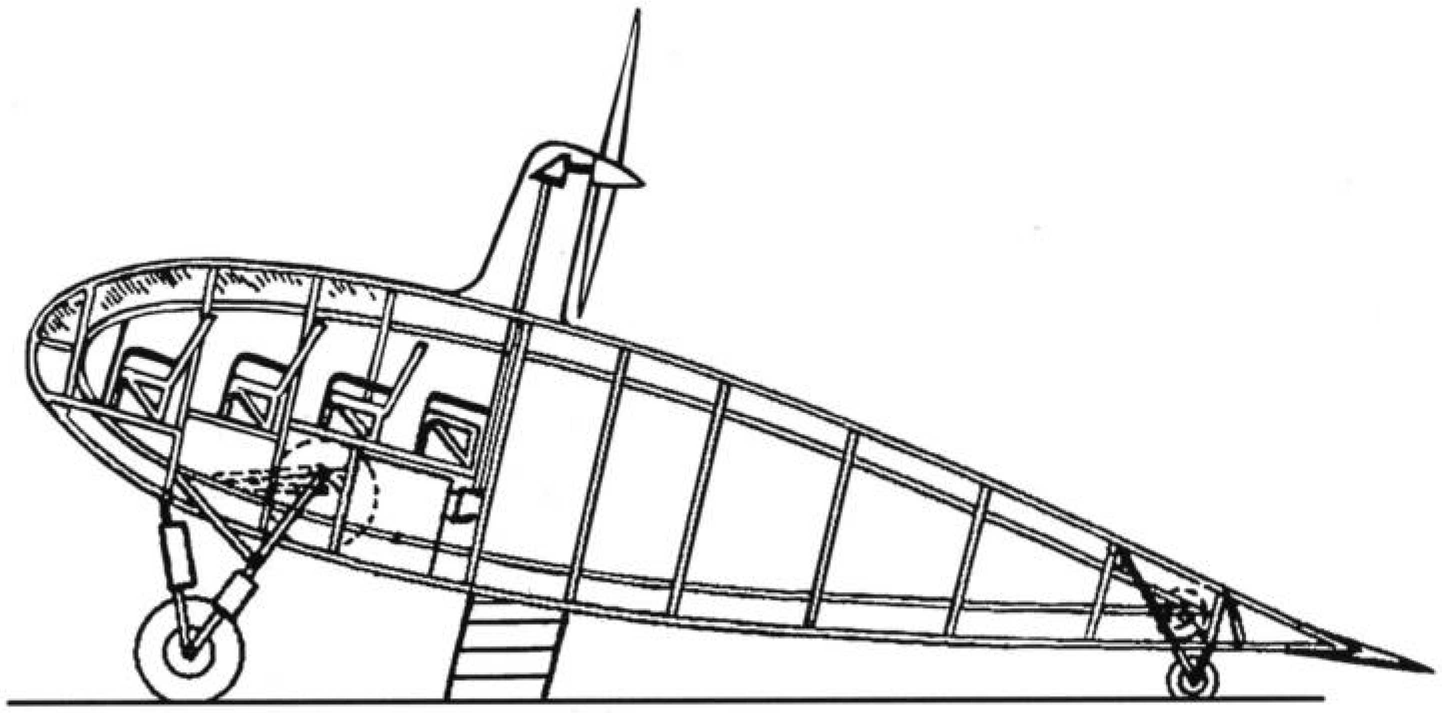
In 1930 Loedding graduated from the Daniel Guggenheim School of Aeronautics at New York University and then he worked for various branches of the US War Department until 1937, when he joined the Bellanca Aircraft Co of Delaware as the manager of their Stress Analysis Department. The following year Loedding joined the USAAF at Wright Field in a civilian capacity, working in various technical departments. As the Second World War gathered pace his expertise was in constant demand, leading to his appointment as a consultant and advisor for the Technical Intelligence Division of Air Material Command (AMC), known as T-2. Loedding was associated with the original Jet Propulsion Laboratory, which was created at Wright Field during World War Two, and he became an expert on wind tunnel design, aerodynamics and rocket propulsion.

Having come from an immigrant German family, Loedding spoke fluent German and he made friends with most of the high-level German aeronautical scientists who had been transported via Fort Bliss to Wright Field after the war. They would be invited to his house for dinner and Loedding developed a good working relationship with most of these former enemies of America. Amongst Loedding's close personal friends were some of the world's top scientists, who included Robert Goddard, Alexander Lippisch and Theodore von Karman. Both Loedding and von Karman were heavily involved with the study and assessment of captured German military aviation technology, which was often forwarded to defence contractors for further evaluation.

By mid-1947 the work conducted by T-2 in Germany and Japan to identify and collect aerospace technology was almost complete. Then a series of hard-to-dismiss UFO incidents took place and Loedding became interested in investigating them. In January 1948 General Nathan Twining, who was in overall command of the Air Technical Service Command at Wright–Patterson AFB (as it had become), asked Loedding if he would be willing to establish a formal office to investigate UFO incidents. Loedding had actually been responsible for suggesting the forma-



Right: **A very advanced flying wing aircraft design, produced by Alfred Loedding during the 1930s. The envisaged propulsion system would probably have proven inadequate.** US Patent Office



Below right: **Cross-section of Alfred Loedding's prewar flying wing aircraft design.** US Patent Office

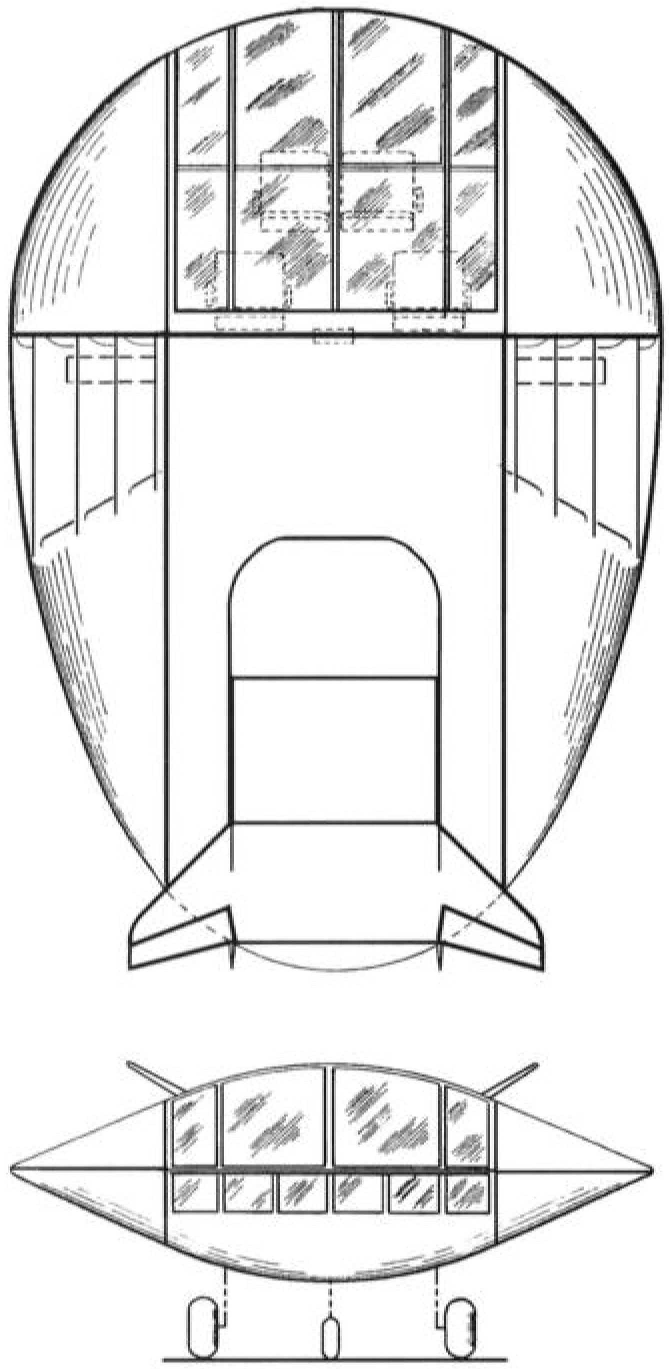
tion of this new department, which he initially called Project Saucer, before the USAF renamed it as the more sedate Project Sign. However, when Project Sign officially started in 1948 there was a real concern from within T-2 that UFOs might be new types of Soviet aircraft.

Why Loedding was so keen to head this department is unclear, but the fact that he had been studying advanced German aviation technology rather intensely for the previous two years, and was on cordial terms with many of the best German designers, does suggest that he had knowledge of things we can only guess at. Needless to say, if the elusive German designer Richard Miethe was taken to America after the war (as would seem to be the case), there can be little doubt that Loedding was involved in his debriefing. While it is debatable just how good Loedding was as a field investigator, he was undoubtedly a superbly qualified, very down-to-earth research engineer who had secured an invaluable amount of high-grade German know-how for the US Government.

By 1948 Howard M McCoy, who headed T-2 Intelligence Section, and his immediate superiors at the Pentagon were largely sold on the idea that Russian flying discs were invading US airspace. Because these craft were obviously developed from advanced Nazi technology, it made Loedding the perfect candidate to head the new investigative department. During the months that followed Loedding's team were requested to study and analyse all the highest profile UFO reports, which included the Arnold Sighting and the Roswell and Mantell Incidents.

One especially interesting UFO sighting that was investigated by Loedding's team took place on 10th July 1947 at Harmon Field. A mechanic working for the Pan American airline had seen an unidentified object that appeared to be powered by turbojet propulsion, which generated a bluish-black trail. This was exactly the kind of report that senior T-2 staff were looking for and they decided that the mechanic had seen a conventional aircraft of foreign origin; as a consequence Loedding's findings were initially classified Secret.

UFO sightings gathered momentum during this period, but Loedding became less certain



Loedding Aircraft design produced in 1948.
via Bill Rose

of what he was dealing with and this didn't go down too well with his military superiors. They were firmly focused on the Soviet threat and had made their minds up that either UFOs didn't exist or they were long-range Russian aircraft. Mass hysteria and mis-identifications were the accepted solutions provided to the public, but behind the scenes Soviet secret aircraft were being taken very seriously. However, when suggestions started coming from Loedding's office that UFOs might be extraterrestrial in origin, this was less than welcome.

By early 1949 Loedding was re-assigned to different work and a new UFO investigation team took over, using the name Project Grudge. This was run by Captain Edward J Ruppelt and reported no evidence of unknown foreign-origin aircraft operating within US airspace, so the Grudge office was finally closed on 27th December 1949. Project Grudge was then replaced by Project Blue Book and the USAF was now primarily concerned with public relations issues as opposed to serious investigation. They continued to gather data that proved useful for analysing public attitudes towards UFOs and reports occasionally revealed sightings of classified operations.

What makes Alfred Loedding especially interesting are his aeronautical designs and post-war work on low aspect ratio aircraft. Loedding had begun to produce serious aircraft designs while he was still a student at the Daniel Guggenheim School of Aeronautics and many of his early ideas mirrored those of Snyder and Zimmerman. On 24th May 1938 Loedding filed a US patent (2,118,254) for a futuristic (although seemingly underpowered) single-engined propeller-driven flying wing aircraft and he continued to develop aircraft designs throughout the wartime period.

On 25th November 1948 he filed another US patent (2,619,302) for an advanced oval-shaped four-seat aircraft with a number of very interesting and previously unseen features. This low aspect ratio vehicle would be powered by a single internal combustion engine or gas turbine, using a ducted fan principle that drew in air through louvres and expelled it via a system of slats at the upper rear between two angled stabilising tailfins with elevons. Loedding was particularly interested in boundary layer reduction and talked at some length about this in his technical notes. He almost intentionally avoided discussion of the aircraft's performance, but seems to have hinted at unusually high speeds. With various ways of ducting the airflow, Loedding envisaged VTOL or at least outstanding STOL performance for his design, undoubtedly depending on engine performance.

His aircraft had the appearance of a well-designed flying saucer fitted with a flush cockpit canopy, supported by a conventional, retractable tricycle undercarriage. Loedding also incorporated various features like opening flaps by the air inlets to permit a controlled descent in the event of an engine failure, and these would act as air brakes during a normal landing. It is known that Loedding built several small models (including at least one completely circular design with a single tailfin), which were wind tunnel tested prior to his patent application. What makes this concept particularly interesting is the fact that it came about during a time when the designer was heavily involved in the study of captured German aircraft technology. The Germans were particularly interested in boundary layer reduction and Loedding's final choice of an elliptical shape may have been influenced by some of the research he evaluated.

Whether this design is somehow connected to the supposed Heinkel/BMW project remains unknown, although Loedding's colleague Dr Theodore von Kardan gave top priority to investigating every aspect of BMW's wartime research when hostilities ceased. Loedding was by all accounts a brilliant scientist and although it may be unfair to deny him full credit for his 1948 aircraft design, it is hard to separate his intense involvement with advanced German wartime aviation, his association with Germany's best scientists and his growing interest in UFO phenomena.

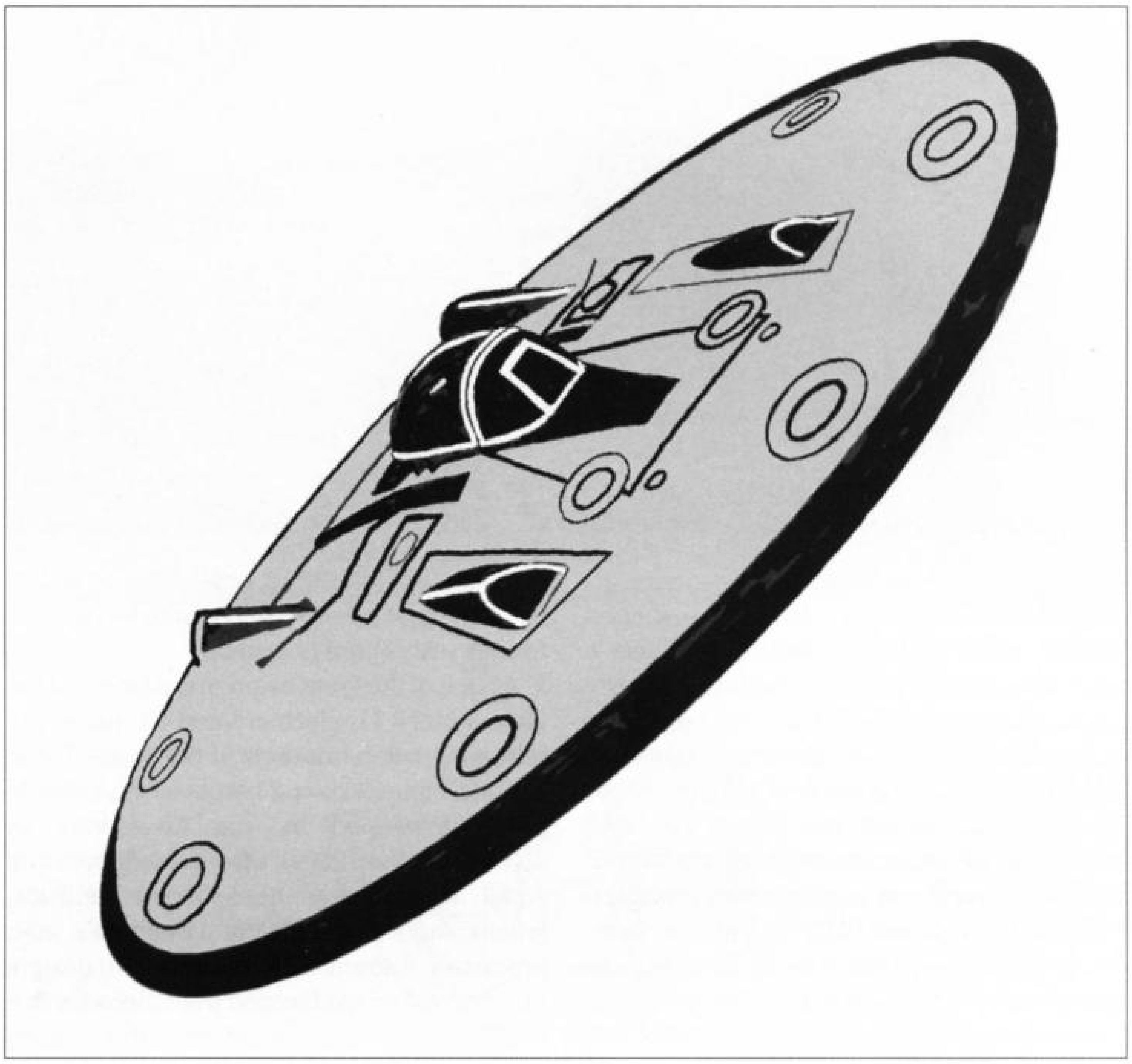
When Project Sign was shut down, Loedding moved back to engineering administration and in 1951 finally resigned from his civilian job with the USAF. He then became Director of Jet Research for the Unexcelled Chemical Corporation at Cranbury, New Jersey, overseeing R&D on missile propellants. Loedding returned to work for the USAF at Wright-Patterson in 1955 and by 1960 he had been appointed the Civilian Liaison Officer with the USAF and NASA. On 10th October 1963 Loedding died in Williamsburg, VA from cancer.

Stasinos Discplane

In November 1950 an engineering graduate called Dick Stasinos, who attended the Northrop Aeronautical Institute, unveiled a detailed tabletop-sized model of a flying saucer, which he is said to have built as part of an Institute project. His design represented a small single-seat circular-winged aircraft with a diameter of approximately 25ft (7.62m) and the vehicle was supported on a retractable tricycle undercarriage. The exact role envisaged for this concept is unclear, but Stasinos almost certainly had a future military application in mind. Like the later saucer conceived by French aeronautical pioneer René Couzinet, this concept would use an outer rotating wing to generate lift, although in this case it was to be powered by eight turbojets. There appear to be circular inlets for the engines dispersed around the disc's upper surface and the exhaust would flow out through the rotating wing. Two separate turbojet engines located on each side of the cockpit would be used for forward propulsion with upper inlets and exhaust ports.

How the disc would be controlled in flight is unclear as there are no visible control surfaces or obvious ways of regulating the exhaust gases. For more than fifty years a photograph of this model has circulated around the UFO community, frequently being referred to as the top secret Northrop flying saucer fighter. The picture has the appearance of a full-sized aircraft waiting on the runway and there have also been suggestions that it was a full sized mock-up built for an exhibition, with various

A drawing of Stasinos flying disc aircraft model circa 1950. Bill Rose



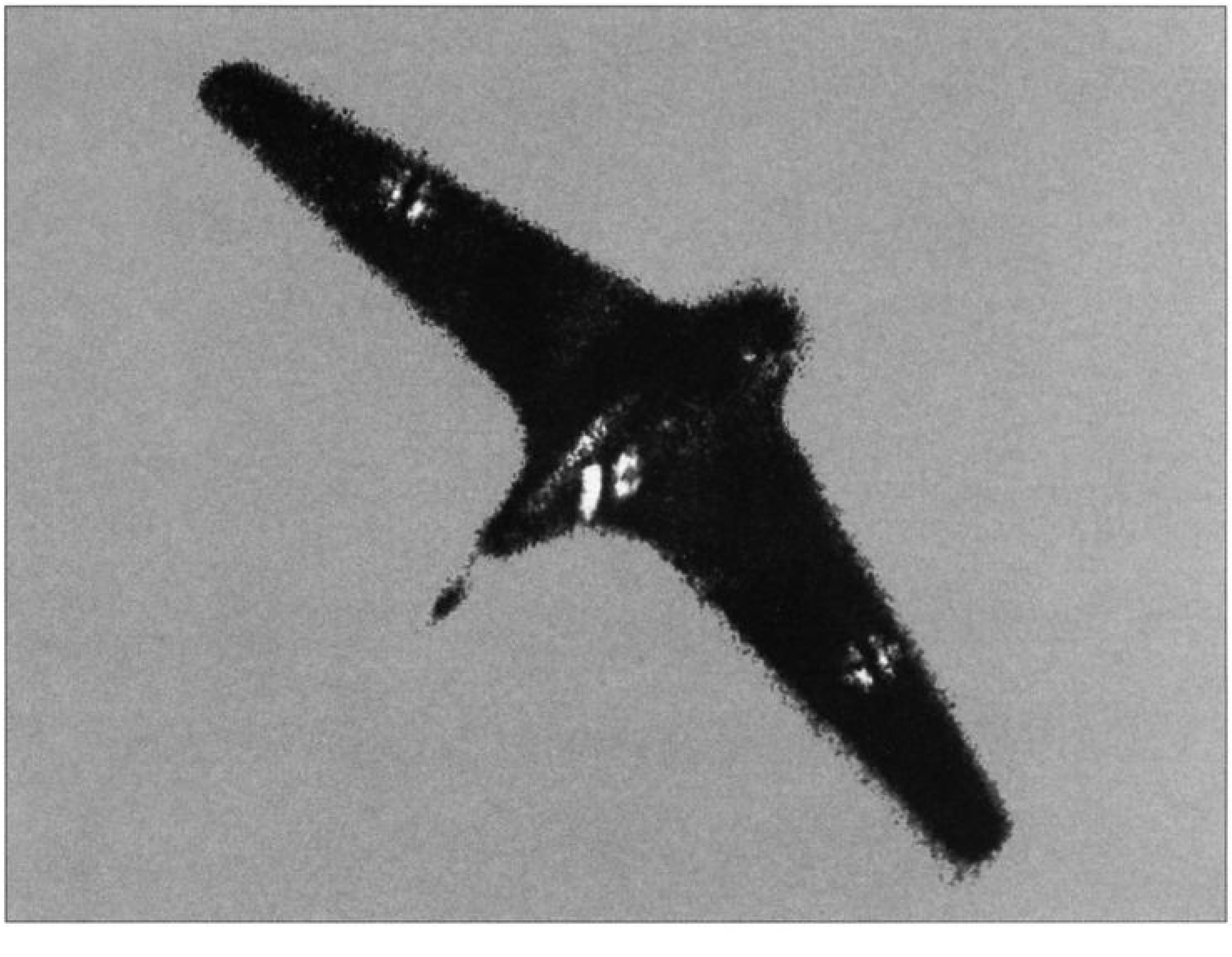
references to the letters and numbers on the fuselage. According to a story originating with UPI in the 1950s, the model was passed to Ripley's *Believe It or Not* Museum in New York. However, Ripley Entertainment's senior archivist Edward Meyer recently stated that the model is not held at any of the company's museums and nobody recalls ever having seen it. What became of the 2ft 6in (7.62m) diameter model is unknown.

Lippisch Heel-Shaped Aircraft

During September 1909 a fourteen-year-old German aviation enthusiast called Alexander Martin Lippisch (1894-1976) watched a flight made by Orville Wright in Berlin. This experience had a profound effect on his thinking and, after returning from military service during World War One, Lippisch joined Zeppelin where he served an apprenticeship and then moved to Dornier as a designer. In his spare time Lippisch worked on plans for tailless gliders and Gottlob Espenlaub built his first full-sized design in 1921. Lippisch continued to investigate flying wings, developing the first delta designs having coined the term 'delta' for this shape. He took the name from the three-sided Greek letter delta, which is actually a triangle.

In 1940 Lippisch was assigned to Messerschmitt where he headed 'Section L' and used his considerable expertise to design the revolutionary Me 163B Komet flying wing rocket-powered interceptor. Dr Lippisch left the programme in 1942, becoming director of the Luftfahrtforschungsanstalt Wien (Aeronautical Research Institute at Vienna: LFW) and began to consider the possibility of designing a successor to the Me 163B that would combine ramjet propulsion with the delta wing to provide supersonic performance.

Postwar image of aerodynamicist Alexander Lippisch. via Bill Rose



Me 163B rocket-powered interceptor captured in action by a gun camera carried by a USAAF P-51. USAF via Bill Rose

An Me 163B Komet begins a 'sharp' start in a cloud of steam, exhausted from a vent below the combustion chamber. Dangerous to operate and fly, the Me 163B was the fastest production aircraft of World War Two. via Bill Rose

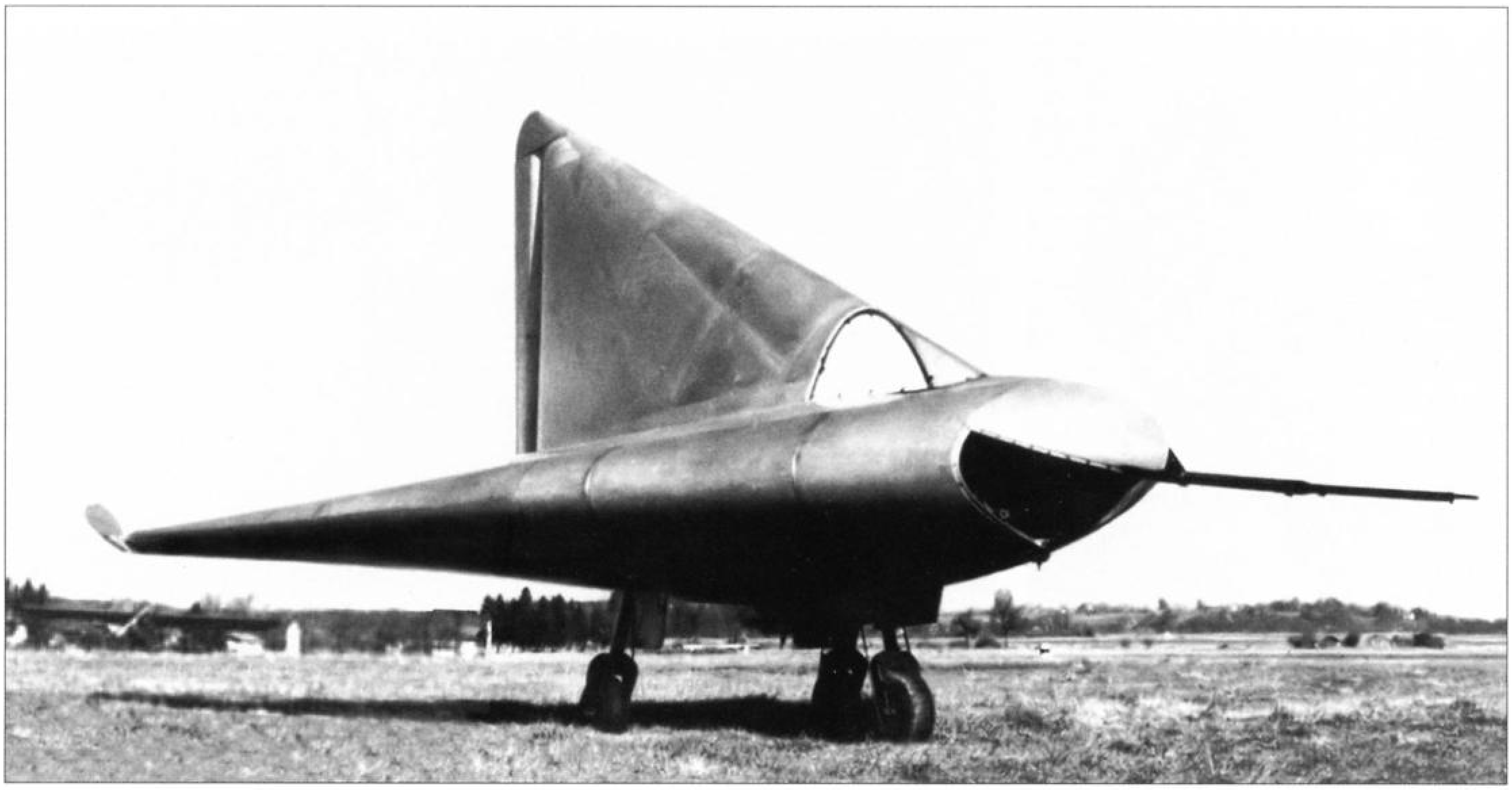
Lippisch completed a series of proposals that led to an experimental triangular-shaped vehicle called DM-1, so named because a team of especially bright students from Darmstadt and Munich Universities were recruited to build it. There were plans to launch the DM-1 glider from the back of a Siebel Si 204 light-transport aircraft and follow the DM-1 with more advanced jet and rocket-powered versions, leading to a supersonic ramjet interceptor. Although the DM-1 had almost been completed by May 1945, it never flew and was captured by US Forces. On the advice of Charles A Lindbergh and the authority of General Patton the aircraft and Lippisch's design team were shipped back to the United States. Lippisch's work was at the cutting edge of aviation research and made an immediate impact on leading British and US designers. After reaching the US, Lippisch finally ended up at Wright-Patterson AFB where he became friends with Alfred Loedding.

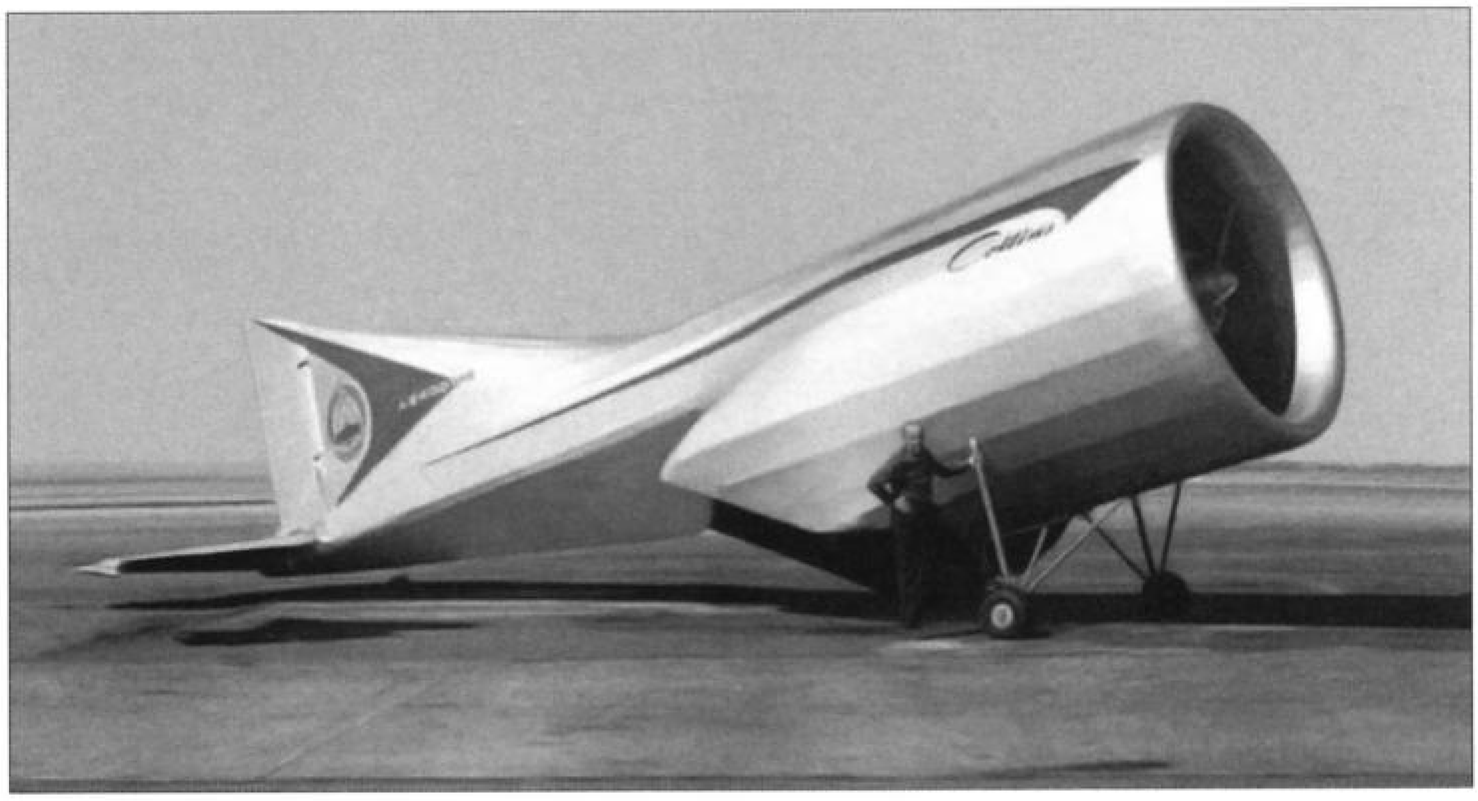
As one of the great aviation designers of the 20th century, Lippisch created all manner of intriguing, often impractical concepts. These included annular-wing aerodynes (similar to those developed by von Zborowski for SNECMA in the 1950s), advanced drones and small lifting body heel-shaped vehicles, which share elements of Loedding's later proposals. It seems likely that the two designers shared and exchanged their ideas for low aspect ratio VTOL aircraft and, after joining the Collins Radio Company, Lippisch began working on plans for a compact lifting body aircraft powered by two internal contra-rotating squirrel cage rotors. One or possibly two engines would drive both rotors, with air being deflected downwards to allow VTOL and a hover capability. Simply known as a 'Fluid Sustained and Propelled Aircraft', this advanced design was completed in 1954, but it remains unclear if it was intended to be anything more than a small utility vehicle. Nothing came of this interesting heel-shaped aircraft and it probably never progressed much further than a paperwork study.

The Skyray

The first American carrier-based jet-powered combat aircraft to combine safety, reliability and performance came about as a result of the US Navy's 1947 Single Engine Fighter Competition. The winning proposal came from Ed Heinemann, Chief Designer at Douglas Aircraft, El Segundo, who drew heavily on research carried out during World War Two by Dr Alexander Lippisch. After a series of initial studies, Heinemann's team refined their concept into a low aspect ratio tailless aircraft with swept wings and rounded tips known as Design or Model D-571. This aircraft

Designed by Dr Alexander Lippisch, the DM-1 experimental glider was the first in a new series of aircraft, which he expected to lead to a supersonic interceptor. US Army





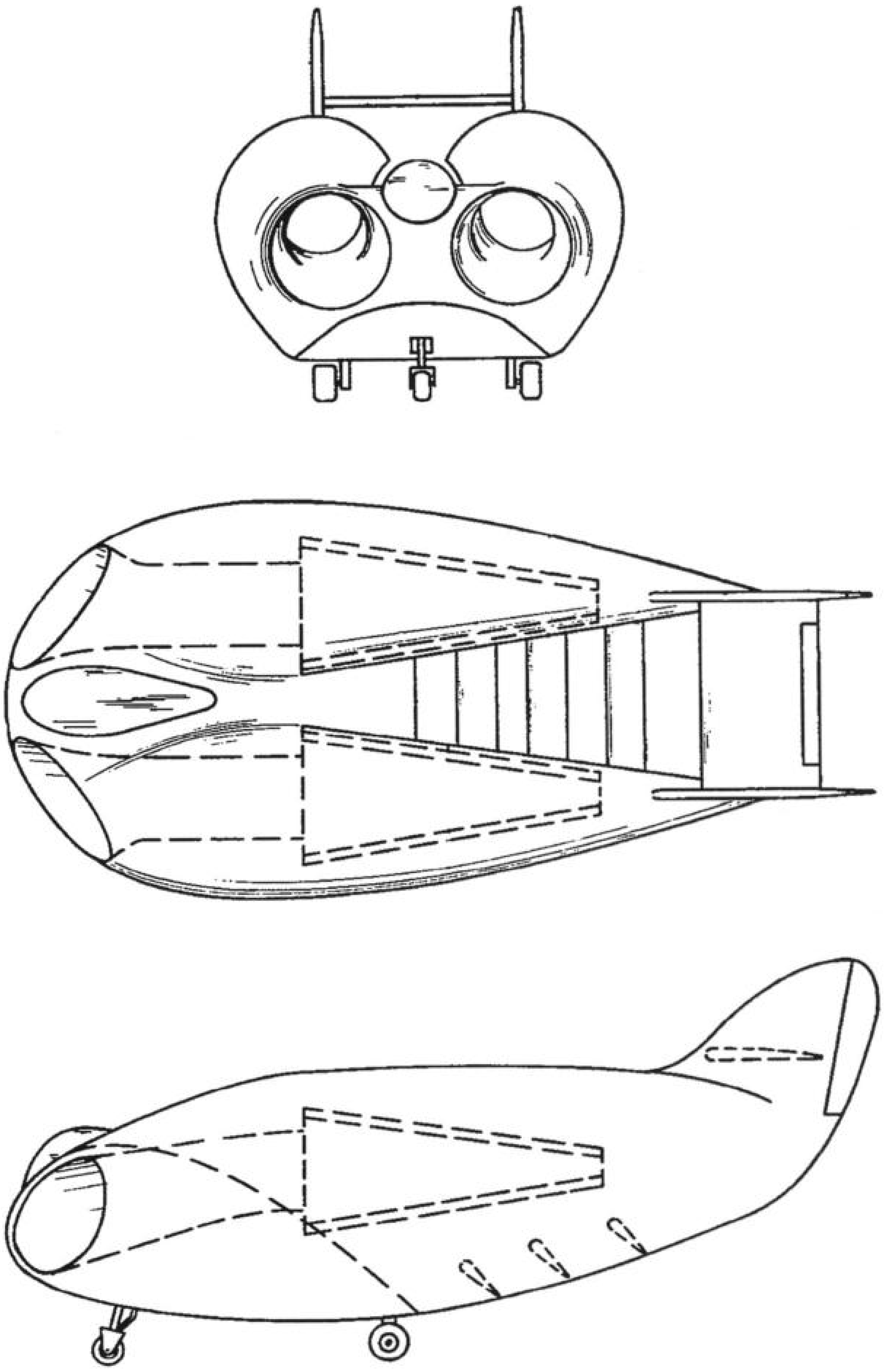
Collin's Aerodyne mock-up. Built around 1959, Lippisch stands next to this incredibly unattractive concept. via Bill Rose

was to be fitted with a new 7,000 lb (31.13kN) static thrust XJ-40 Westinghouse turbojet and wind tunnel testing of D-571 models indicated that the engine would provide the potential for supersonic speed in level flight.

Initial trials exceeded expectations and the US Navy commissioned the construction of two full-sized D-751 prototypes, allocating the designation XF4D-1 during December 1948. Later the name Skyray was adopted which reflected the aircraft's very unusual sleek manta-ray shape. The Navy specified the Westinghouse XJ40-WE-6 engine for this aircraft but, aware of the engine's troublesome reputation, Heinemann rather thoughtfully designed the airframe to take any jet engine up to 42 inches (1.06m) in diameter, which allowed the use of several alternatives. With a length of 45ft 5in (13.84m), a wingspan of 33ft 6in (10.21m) and a wing area of 557sq/ft (51.8sq/m), the Skyray was more or less the same size as the troublesome Vought Cutlass and it could be folded up into much the same space for hangar storage. Proposed armament for the Navy's new Skyray was four 20mm cannons, which would be supplemented by air-to-air missiles as they became available.

By June 1950 the Westinghouse XJ40 was still undergoing development and a decision was taken to fit the XF4D-1 prototypes with less powerful Allison J35-A-17 turbojets rated at 5,000 lb (22kN) static thrust. The first XF4D-1 flight took place on 23rd January 1951 at Edwards AFB and, although there were some technical problems, the aircraft reportedly handled fairly well. Westinghouse finally provided XJ40-WE-6 turbojets for the programme but serious problems persisted and in March 1953 a decision was made to switch to the more powerful newly developed Pratt & Whitney J57-P-2 axial flow afterburning engine, which had an anticipated rating of 10,000 lb (44.48kN) static thrust. As things worked out the ill-fated J40 proved to be a turning point for Westinghouse, who were forced to pull out of jet engine manufacturing completely.

The re-engined F4D-1 (later re-designated F-6A) now showed itself to be a more capable aircraft than initially envisaged, with a top speed approaching Mach 1 and a service ceiling in excess of 50,000ft (15,240m). Maximum loaded weight was 27,000 lb (12,247kg) and with drop tanks this allowed a range of about



A postwar design by Alexander Lippisch for a heel-shaped ducted fan aircraft. US Patent Office

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This page:

US Navy Douglas F-4D Skyray over San Diego, California. US Navy

Douglas F-4 Skyray. US Navy

Douglas F-4D Skyray lands on USS *Bon Homme Richard* in 1957. US Navy

Opposite page:

Top left: **Douglas Skyray, 3-view drawing.** US Navy

Top right: **An early design for a ducted fan flying saucer produced by Edmond Doak.** via Bill Rose

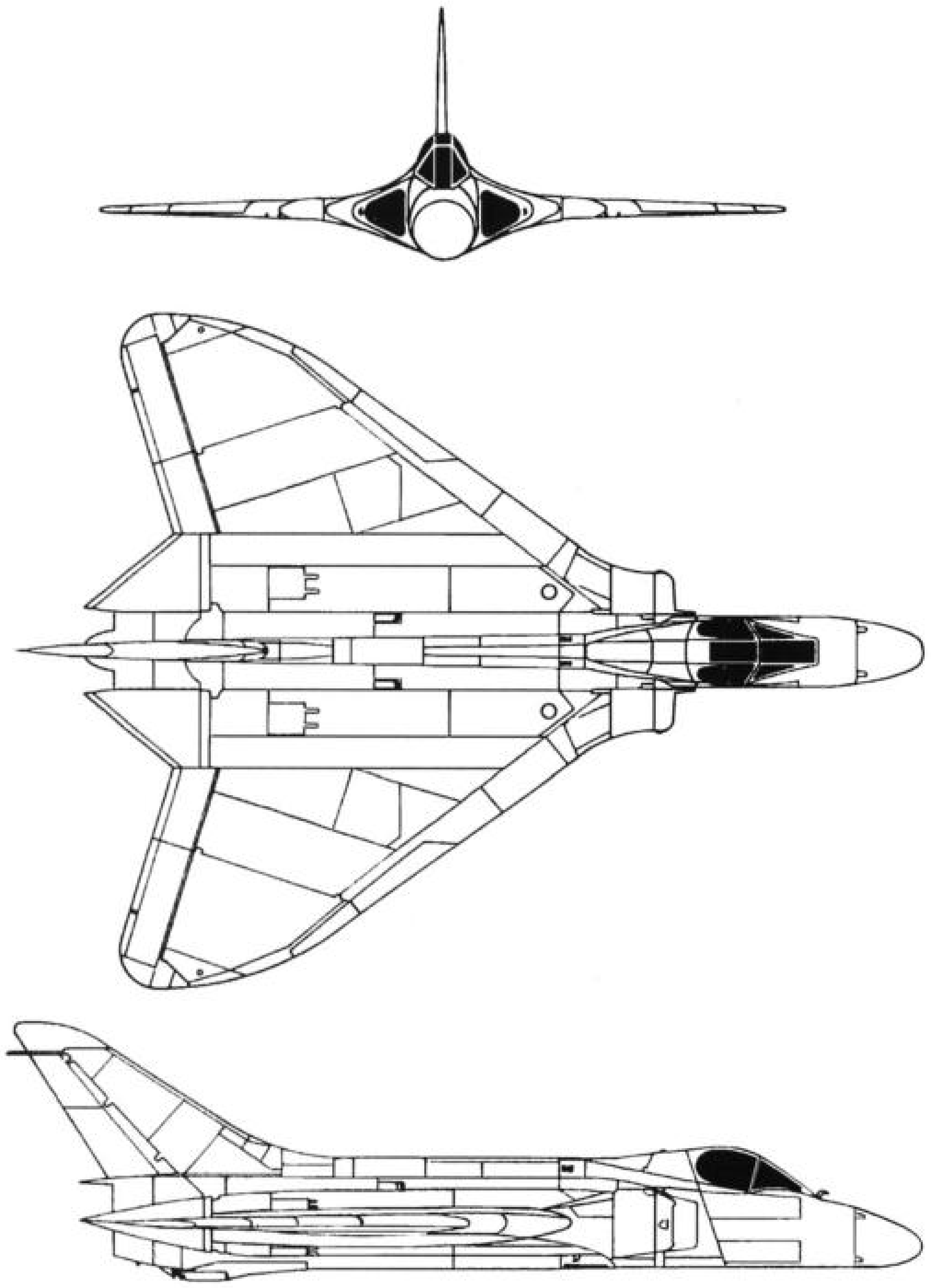
Bottom: **The experimental Doak Model 16 VTOL test aircraft.** Doak Aviation

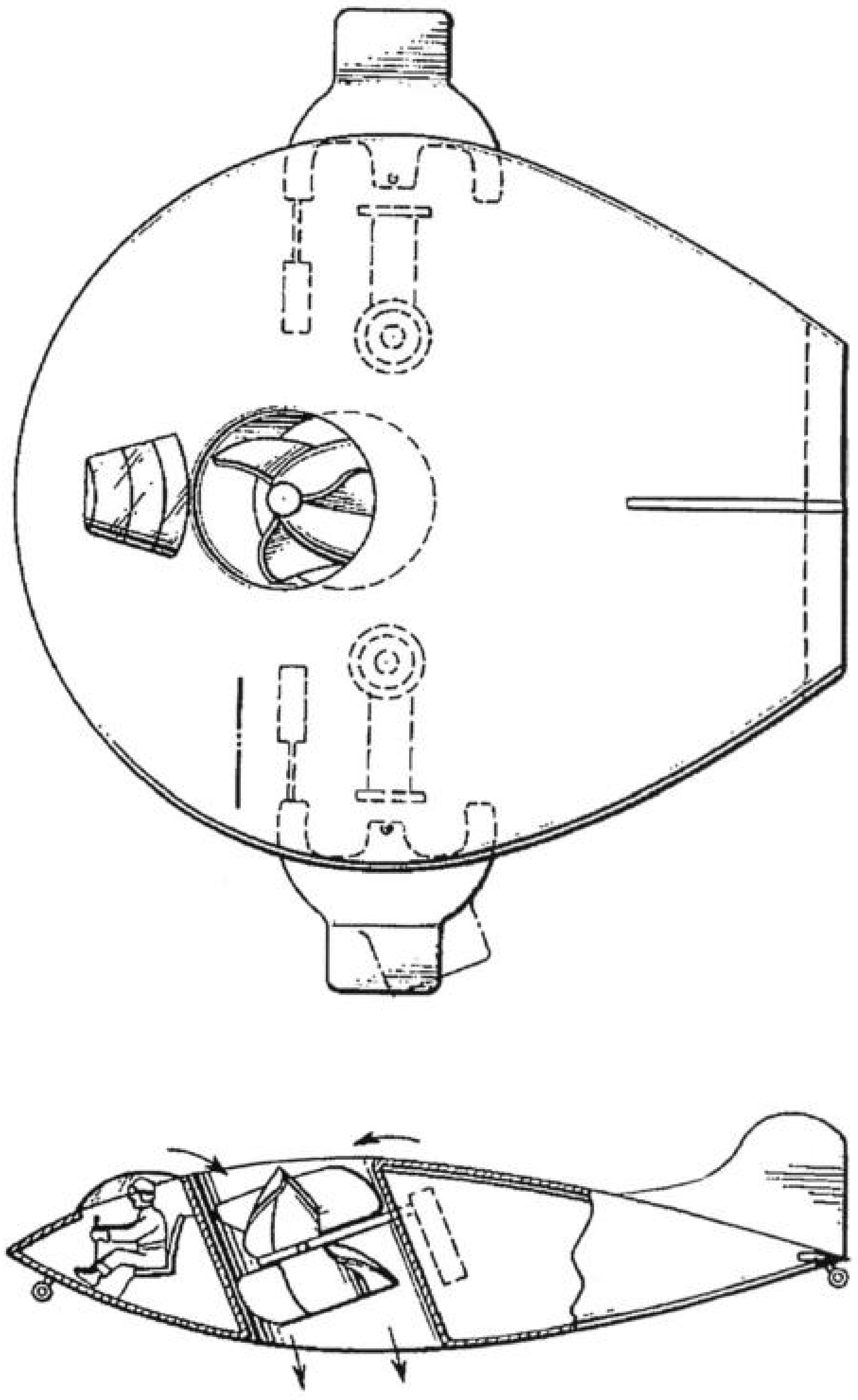
700 miles (1,126km), depending on the mission profile. A total of 421 Skyrays were built between 1954 and 1958 and the last aircraft in Navy service were replaced by F-4B Phantoms during 1964. The Skyray, which became known as 'The Ford', never saw combat but it was deployed to several trouble spots including Taiwan in 1958 and Guantanamo in 1962. The Skyray was eventually followed by a compact naval attack aircraft called the A-4 Skyhawk, which entered production in 1954 and continued to be built until 1979. Some 2,980 copies were sold to the US Navy, Marine Corps and a number of overseas customers making it one of the company's most successful products.

It might be argued that the Skyray does not belong in a book that predominantly deals with exotic circular-winged designs. However, its low aspect ratio manta ray-shape was strikingly unusual and the favoured bright external finish was undoubtedly responsible for generating numerous reports of unidentified flying objects during the aircraft's time in service.

Doak's VTOL Ambitions

Edmond Rufus Doak (1898-1986) was born in Texas. His family relocated to California in December 1910 and two years later he joined the Glenn Martin Aviation Company in Los Angeles as a trainee. He then worked for North American Aviation and moved on to Douglas, becoming the General Manager and Vice President of Douglas-El Segundo. In 1939 Doak left Douglas to start his own business at Hermosa Beach, California, called the Doak Aircraft Co. As sub-contractors, the company built fuselages for Vultee and North American, along with numerous smaller components for most of the major Californian aviation companies. By 1945 Doak employed more than three thousand women on war production although the company down-





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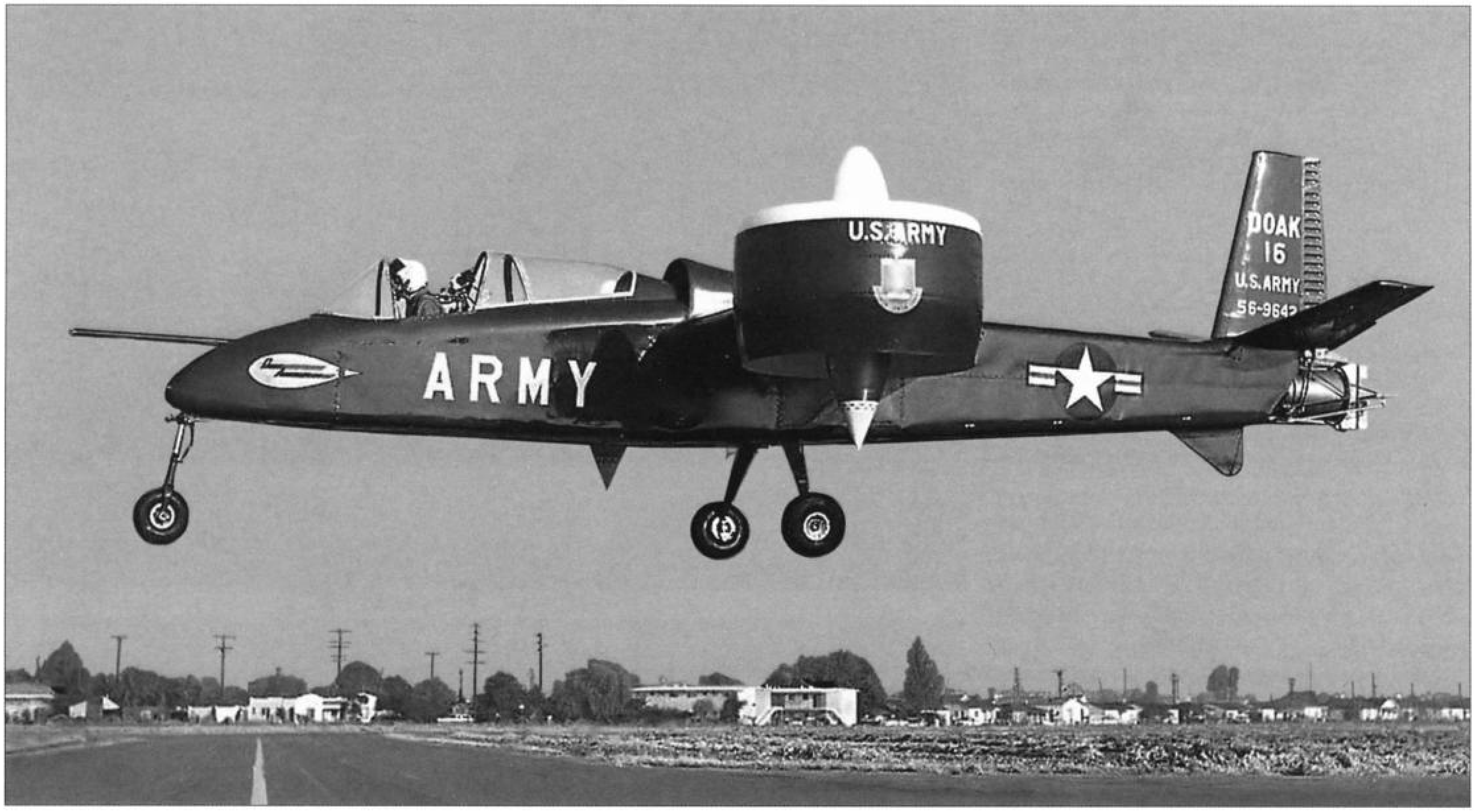
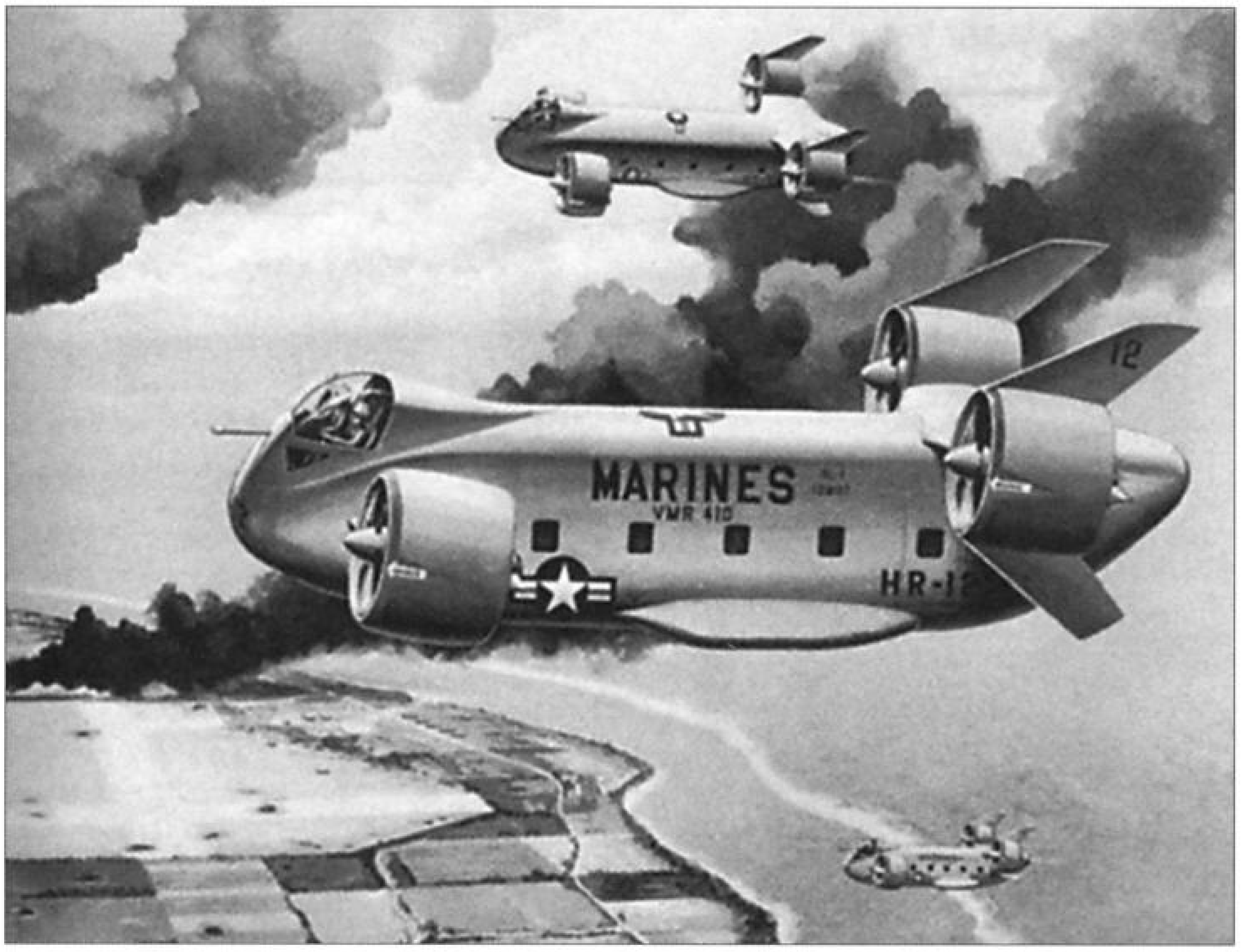


The Doak Model 16 experimental VTOL aircraft flown by Jim Reichert makes a test flight in 1958 at Torrance Airport, California. Doak Aviation



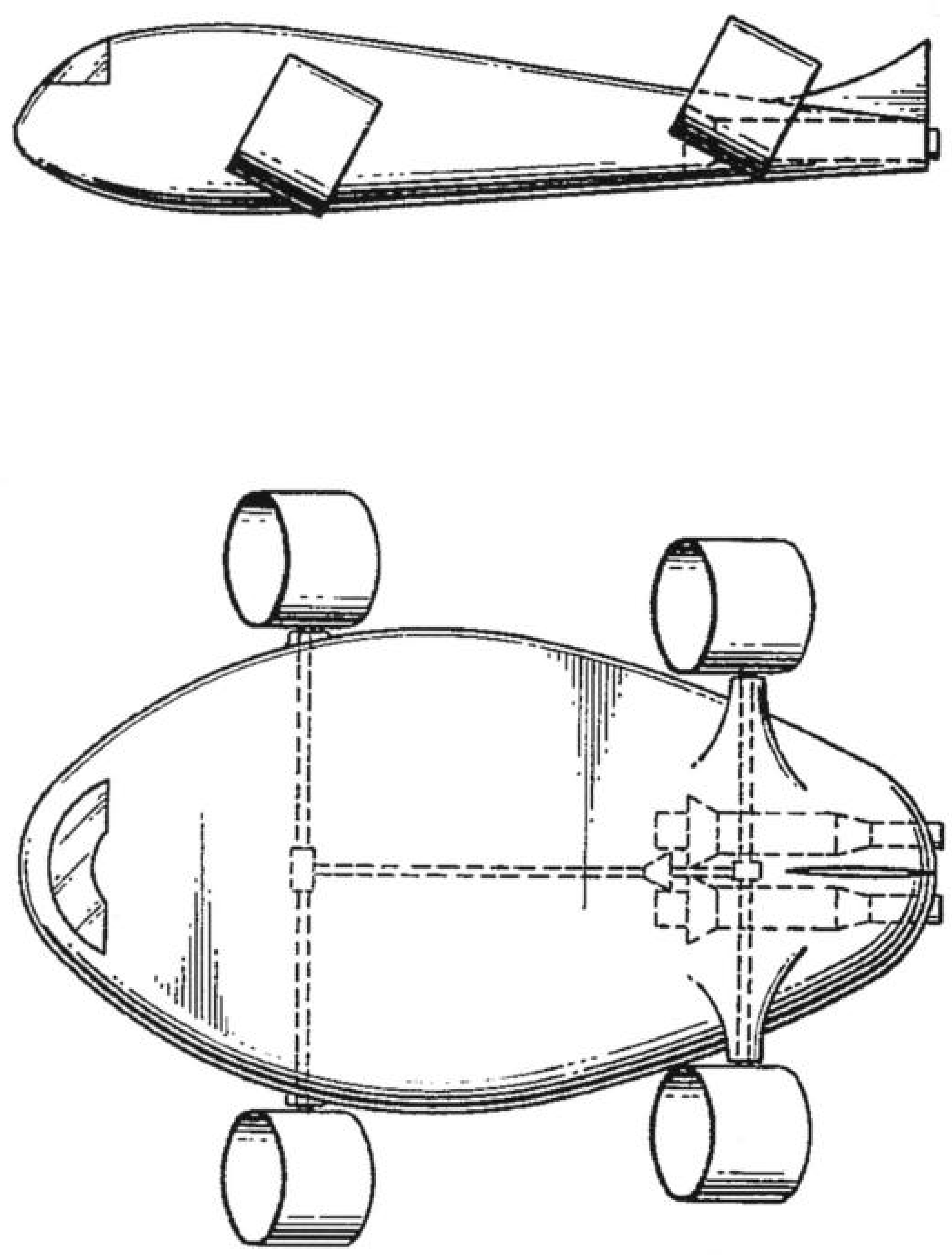
Similar to the Doak oval-shaped VTOL design, the Bell D-2022 concept for a ducted fan assault helicopter was not taken up by the Pentagon. Bell Aviation

sized in peacetime, diversifying into items for the general consumer market. Although they continued to manufacture a wide range of aviation components, Edmond Doak became increasingly interested in helicopters, ducted fans and VTOL concepts, with ideas of moving the company into the bigger league of aircraft constructors.

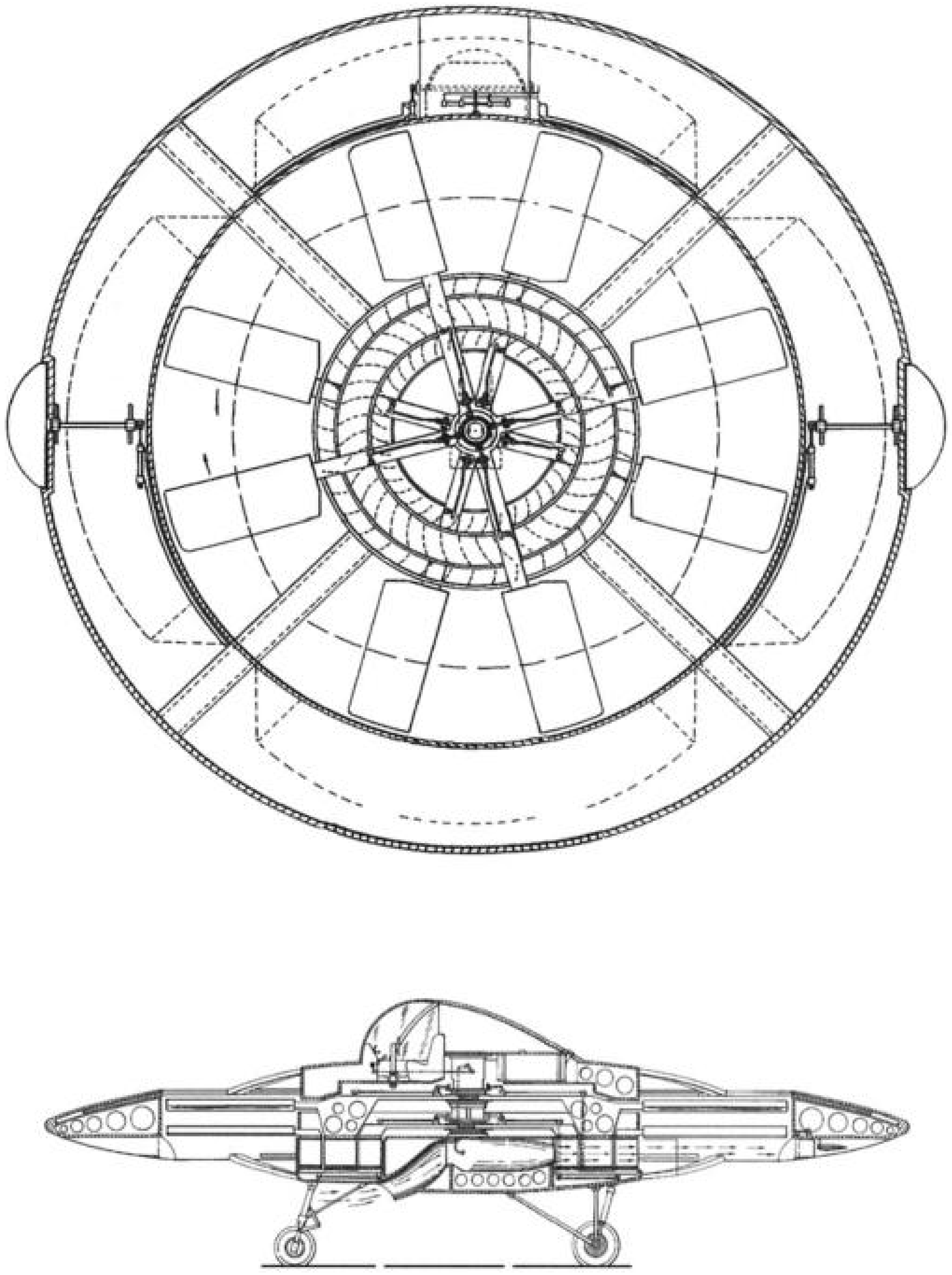
By 1950 Doak had secured official interest in the development of a new two-man flying disc aircraft, which utilised ducted fan propulsion. Doak expected the aircraft to have a full VTOL capability and envisaged the use of two contra-rotating co-axial rotors inside a central duct, which would eliminate any torque problems and channel air downwards beneath the aircraft and to the rear for horizontal flight. While the development of this concept appears to have been undertaken in conjunction with the USAF, there is no indication of exactly what role was envisaged for this aircraft.

Although nothing came of his flying disc, Doak continued to work on VTOL projects and by 1954 a series of new designs had been completed for aircraft with swivelling ducted fans that were capable of providing lift and horizontal flight in excess of anything available from a helicopter. With considerable assistance from the company's chief engineer Norman Nelson and aerodynamicist/ test pilot Jim Reichert, a more practical design emerged and this attracted a development contract with the US Army that was issued on 10th April 1956. The funding made it possible to complete a proof-of-concept prototype known as the Doak M-16, but officially designated VZ-4DA, with the serial number 56-9642.

The VZ-4DA was 32ft (9.75m) in length and had a wingspan of 25ft 5in (7.74m). The gross



An advanced oval-shaped VTOL ducted fan concept produced by Edmond Doak in the late 1950s. This was the anticipated next stage on from the Model 16. US Patent Office



An unusual flying saucer design produced in 1957 by John Davis, a Texas-based aerodynamicist. via Bill Rose

weight of the aircraft progressively increased during development, reaching 3,180lb (1,443kg). Maximum speed was never a major issue with this prototype, but the aircraft was capable of reaching about 230mph (370km/h) in level flight. Propulsion took the form of a Lycoming T-53-L-1 turboshaft engine rated at 840hp (626kW), which was located in the fuselage and coupled to the ducts by shafts.

The VZ-4DA made its first test flight on 25th February 1958 at Torrance Airport, with Jim Reichert at the controls. This initial test programme was completed by June 1958 and the aircraft was then moved to Edwards AFB during October 1958. After a further fifty hours of flight-testing, the US Army formally accepted the aircraft and it was moved to NASA-Langley for further evaluation in 1960. The VZ-4DA performed reasonably well, although it exhibited a fairly severe nose-up tendency during transition from hover to forward flight and it was generally accepted that the T-53-L-1 engine provided insufficient power and need to be replaced with something offering better performance.

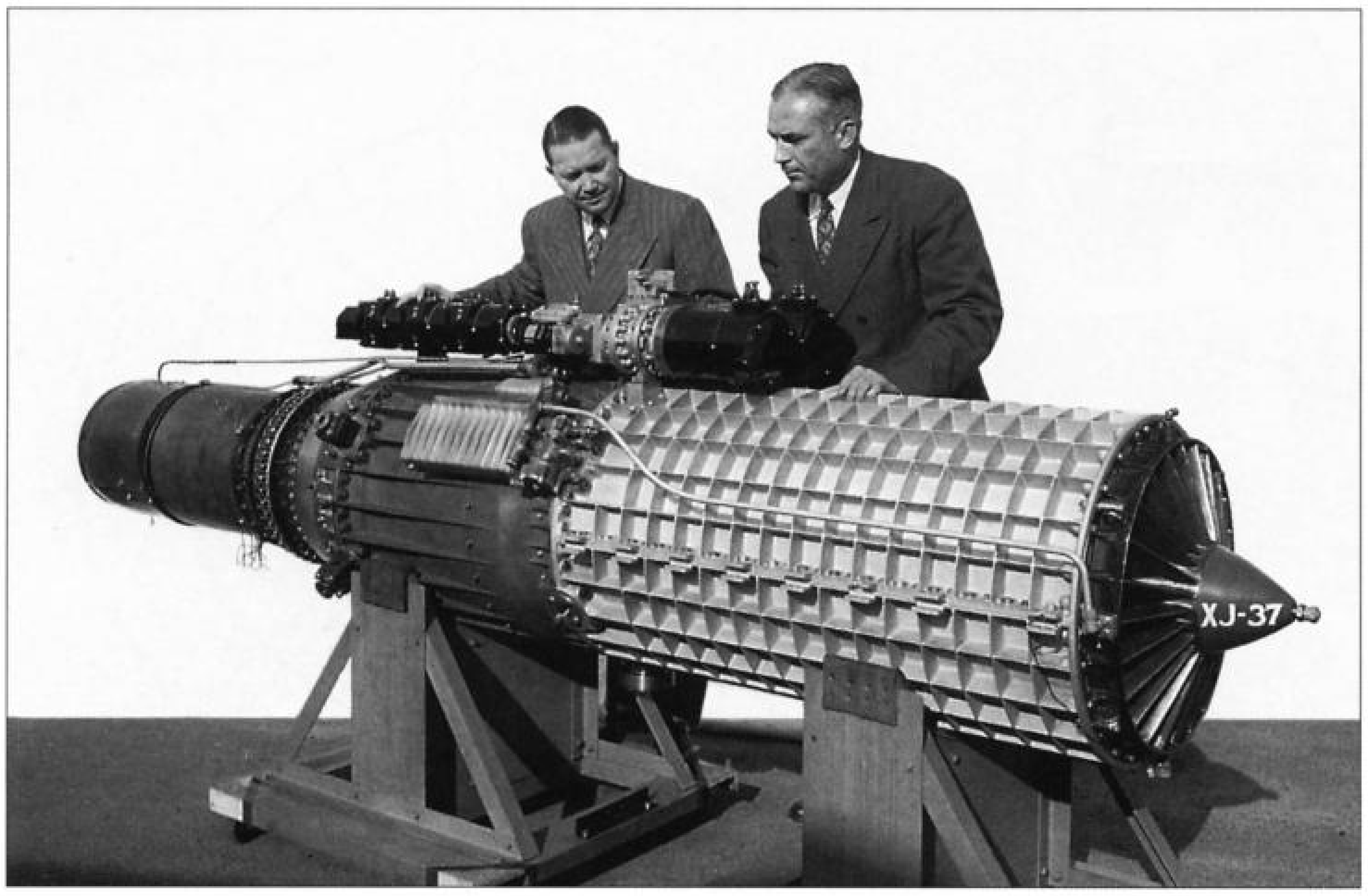
Throughout the 1950s Doak developed advanced concepts that used the same engineering principles as the VZ-4DA and he envisaged the successor to this proof-of-concept demonstrator as a wingless elliptical craft, with four separate fans. The ducted unit would be shaft-driven by a pair of gas turbines, which were capable of propelling the aircraft at relatively high speed in level flight. By coincidence, in 1959 Bell Aircraft produced two somewhat similar designs known as the D-2005 and D-2022. Both were intended to be assault transporters capable of carrying up to thirty soldiers.

However, Doak Aviation closed for business during 1961 and the rights to the VZ-4DA and all the R&D material were sold to Douglas Aviation in Long Beach, who did not exploit the concept further. The VZ-4DA remained at NASA-Langley until August 1972 when it was finally presented to the US Army Transportation Command Museum at Fort Eustis, where it is currently on display. Norman Nelson joined Lockheed's highly secretive Skunk Works, becoming involved with the A-12/SR-71 project; later he was appointed as project manager for the F-117A stealth interdictor. Jim Reichert also joined Lockheed, working on radar-absorbent materials for the F-117A.

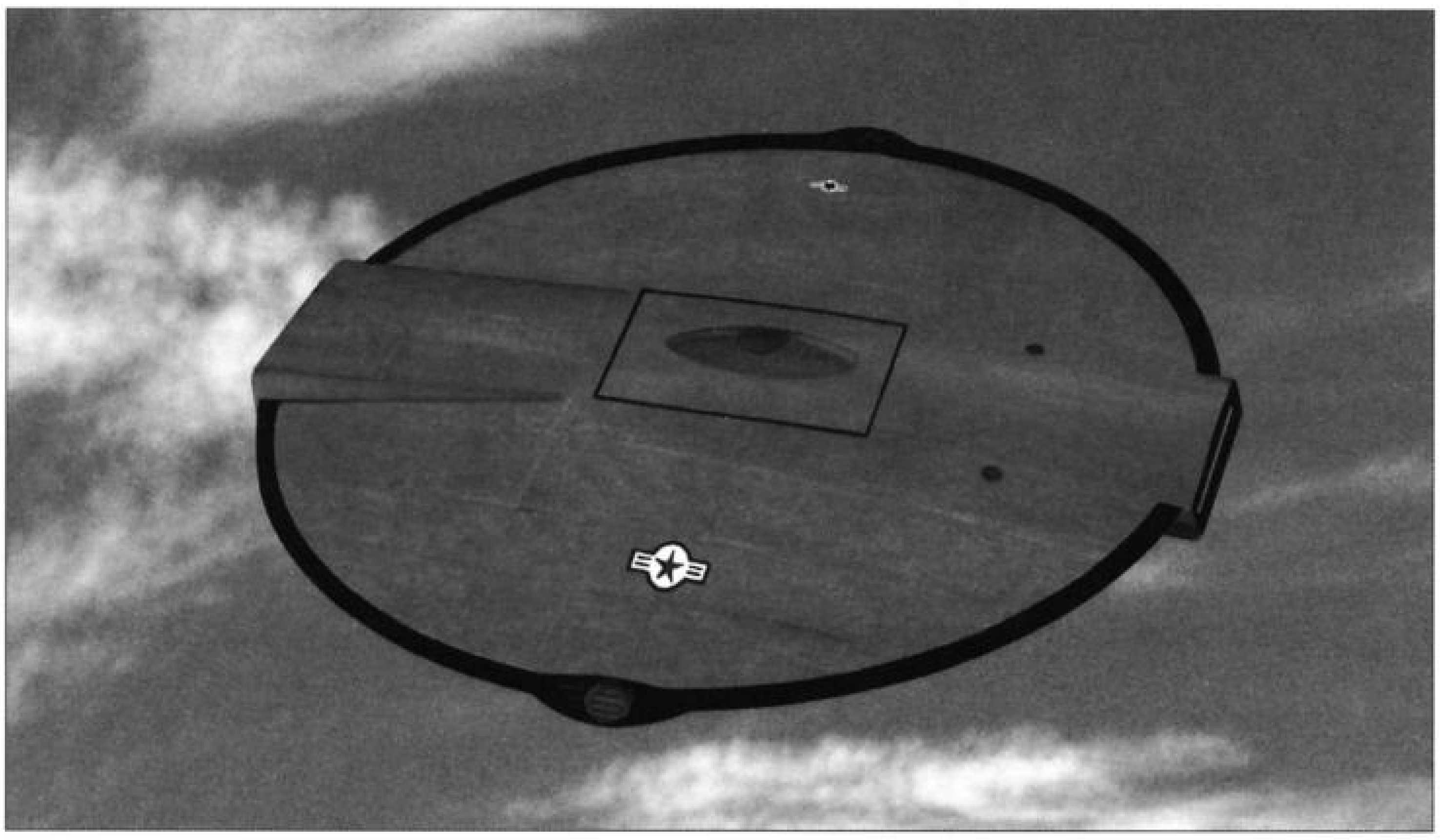
Davis Flying Saucer

Throughout the 1950s, most of the major defence contractors were secretly undertaking or commissioning independent consultants to carry out design studies of circular-winged aircraft. Propulsion using an enclosed rotor system gained considerable favour and Texas-based designer John W Davis produced an interesting concept, which was reviewed by several contractors, but there were no takers for further development.

Nevertheless, Davis applied for a patent in 1957 and the design of his Silver Bug-sized aircraft does have several interesting features. Intended for a military role, the aircraft had a centrally mounted single-seat cockpit with a blister canopy. The lenticular-shaped fuselage contained two rotor blade assemblies, each with four arms on a common central bearing. These were contra-rotating to elimi-



Hall Hibbard (left) and Nathan Price (right) beside an example of the experimental XJ-37 L-1000 axial flow gas turbine. Lockheed-Martin Skunk Works



Artwork showing the Lockheed high-altitude VTOL ramjet-powered flying disc in flight. Bill Rose

nate torque. Powering the rotors would be a jet engine with a forward-facing ventral air intake, with the exhaust gas being used to turn a lower turbine coupled to the rotor assemblies. Davis believed this arrangement would allow full VTOL operation, hover and high-speed level flight. Small ailerons on each side of the fuselage and a vertically extending rudder would assist flight control and the aircraft was supported by retractable tricycle undercarriage. Davis said that his design would be cheap to build and efficient in action. However, translating this idea into a reliable working machine might have presented some major engineering challenges.

Lockheed Skunk Works Saucer Studies

Lockheed's Skunk Works in California has gained an enviable reputation within the aviation industry as a prestigious centre for advanced, often highly classified design work. The name Skunk Works accidentally came into use during World War Two when a Lockheed designer called Irv Culver picked up the phone one day and said, 'Skonk Works, inside man Culver speaking!' Culver had taken the name from an Al Capp comic strip and Skonk Works was soon in widespread use by company employees. As the name began to stick, Lockheed's management made a slight change and then officially adopted it as The Skunk Works.

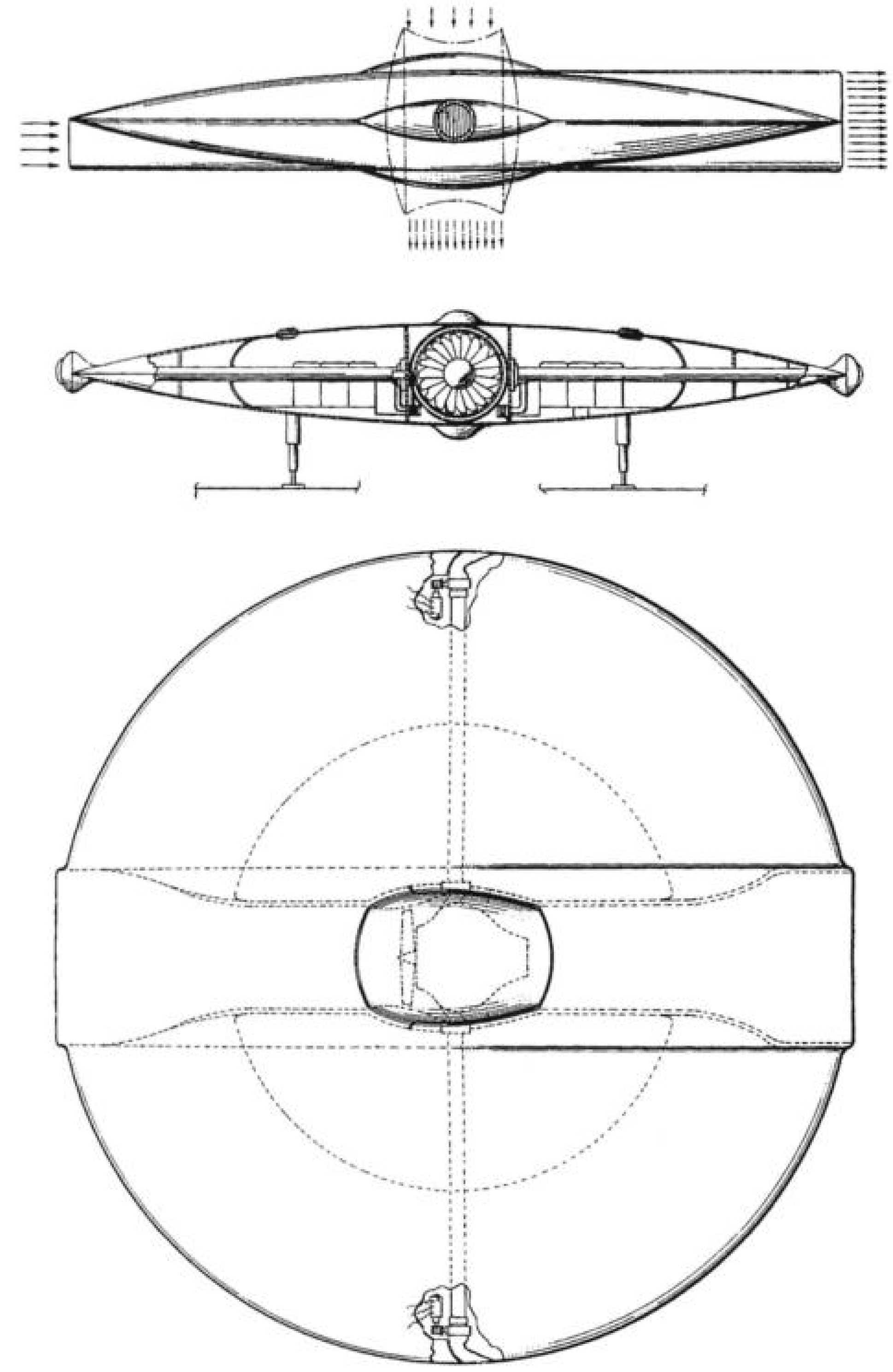
Many black project aircraft have been created by Lockheed's Skunk Works. It was originally based at Burbank, Los Angeles, but the entire facility had relocated to Palmdale by 1992. The first significant classified project undertaken by the Skunk Works was the XP-80 jet fighter, which began life in great secrecy at Burbank Plant 6 during 1943. The XP-80 was essentially the amalgamation of a British jet engine with a new Lockheed airframe and it proved to be very successful. The two company employees who made the whole thing possible were Hall Hibbard and Nathan C Price.

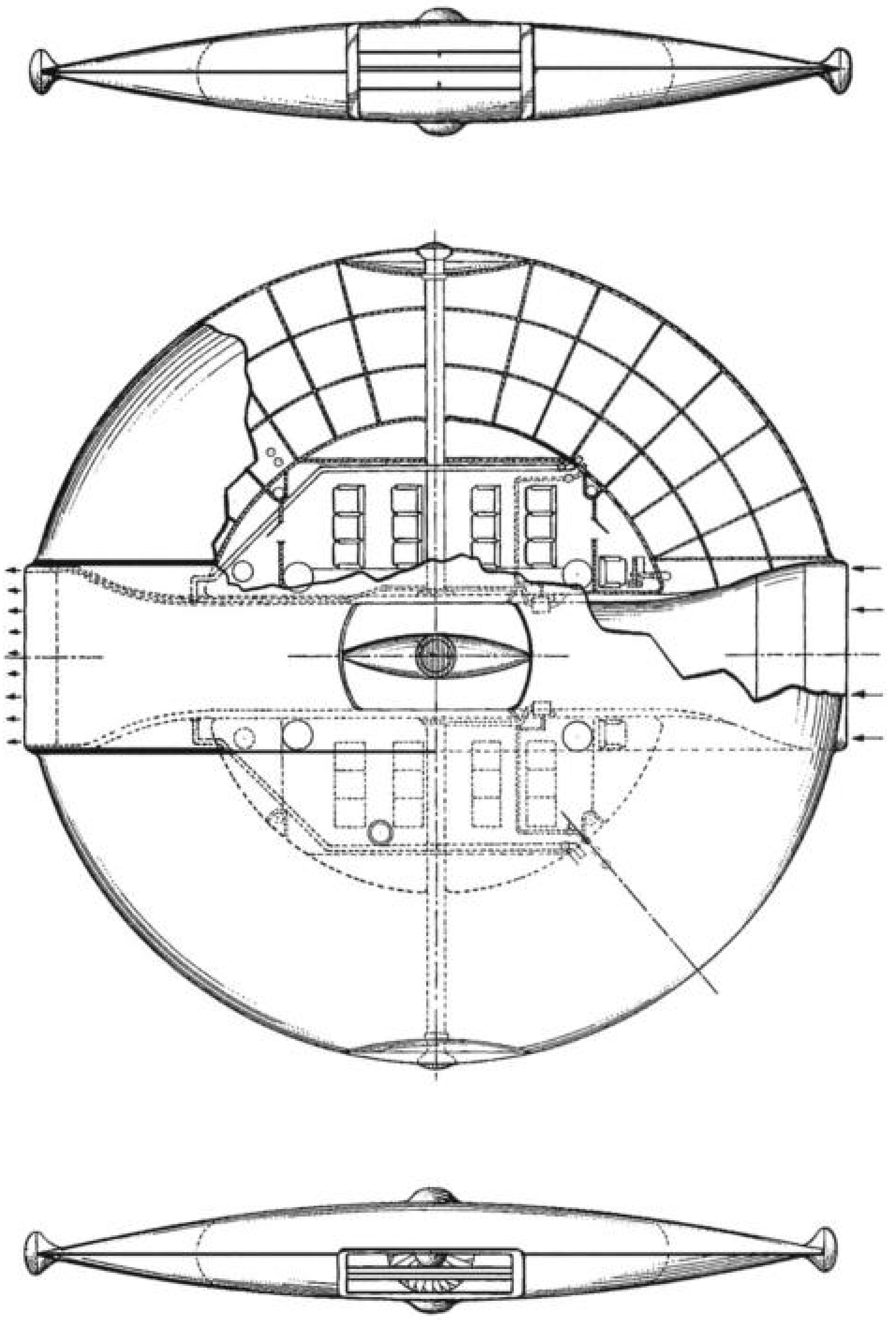
Nathan Price had originally been employed by Doble Steam Motors as an engineer and worked on several very unusual projects like the Besler biplane, which flew in 1933 and remains the only fixed-wing aircraft to have been powered by steam. He joined Boeing soon after this and then moved to Lockheed, where his engineering expertise gave him a definite advantage with gas turbine development. During the early 1950s Price became particularly interested in the design work of aerodynamicists like Alfred Loedding and may have been under pressure to create a competitor to Avro Canada's Project Y flying saucer.

Lockheed has always been an aggressive force in the marketplace and they are not the kind of company to leave any stone unturned, so the design of an alternative aircraft was hardly unexpected. Having assembled a small team to work on disc-shaped aircraft, the first project was a high-performance, high-altitude flying disc aircraft. Illustrative graphics show this design as a passenger-carrying VTOL aircraft with a large central duct containing a powerful turbo-ramjet propulsion system.

The engine unit, described as an 'island', would swivel downwards for VTOL operations and in level flight the system would operate entirely as a ramjet, with the compressor 'windmilling' and exhaust gases flowing through a series of louvres and outlets at the rear of the aircraft. There was a single rectangular-shaped engine inlet at the lower front of the craft to feed the turbo-ramjet system and the crew were accommodated in two cockpits on either side of this inlet. Passengers were seated, facing rearward, on each side of the centrally positioned turbine and there were shaft-driven fans at each wingtip providing additional control of exhausted gases. Variants might have used more than one gas turbine in a central cluster.

The overall design looks very complex, rather ugly and conditions inside the cabin area might have been unacceptably noisy. It

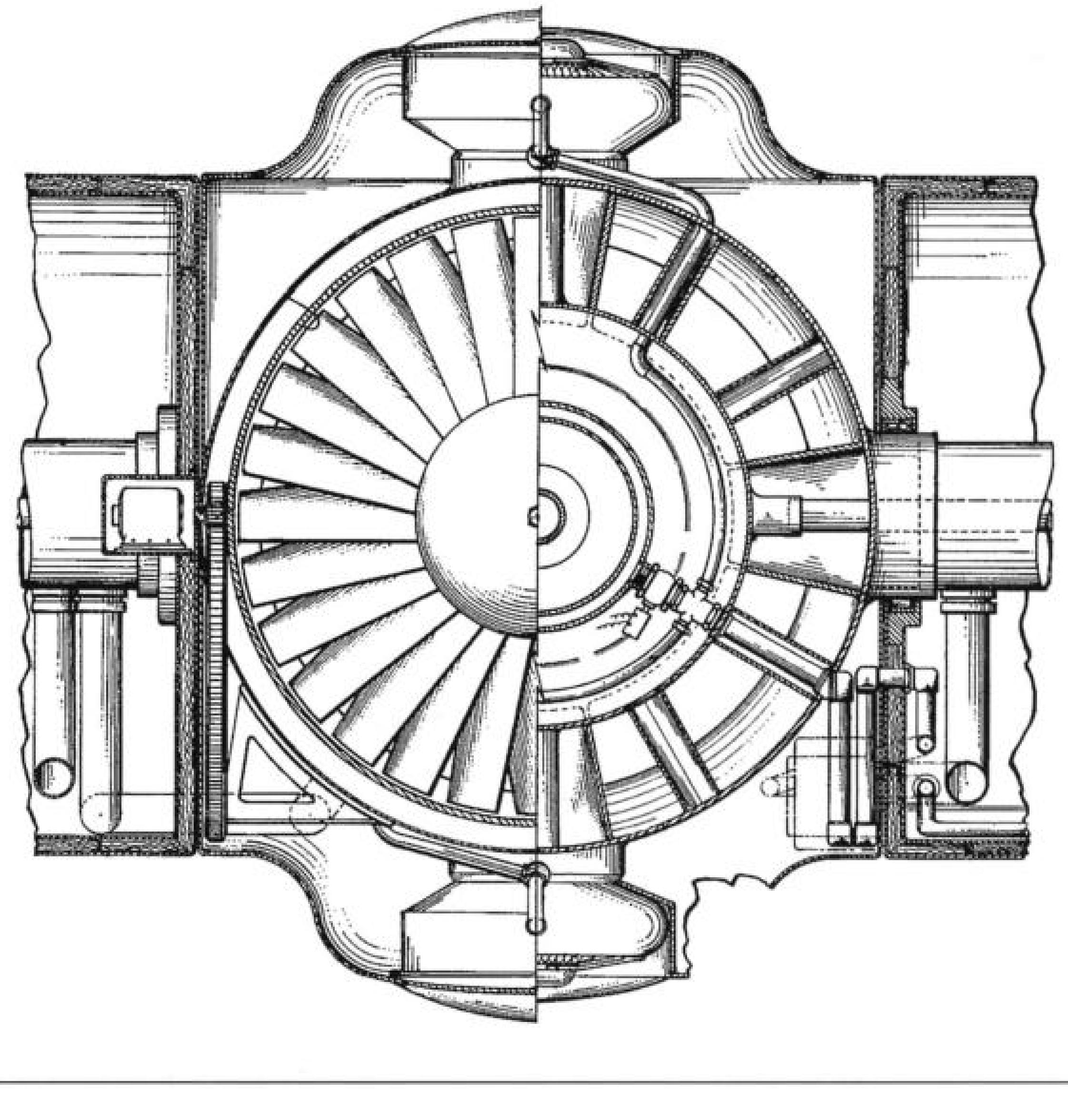




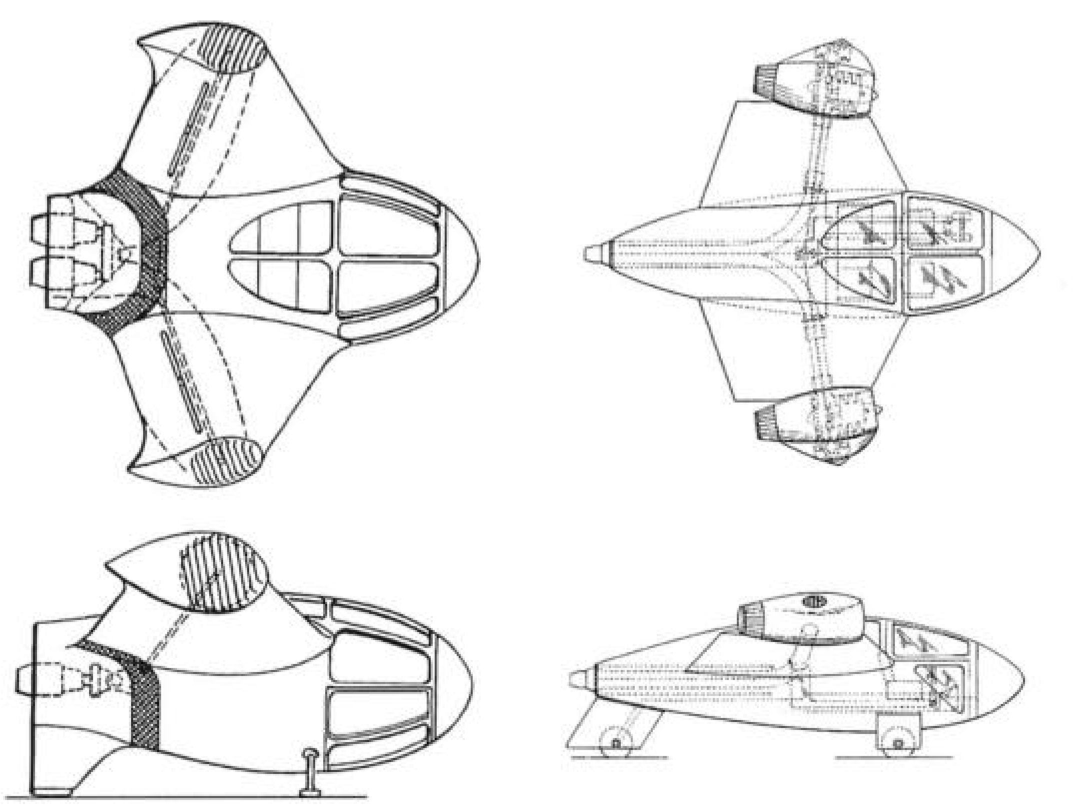
Above left: **Three-view drawing of the Lockheed ramjet-powered VTOL flying disc designed by Nathan Price during the early 1950s.** via Bill Rose

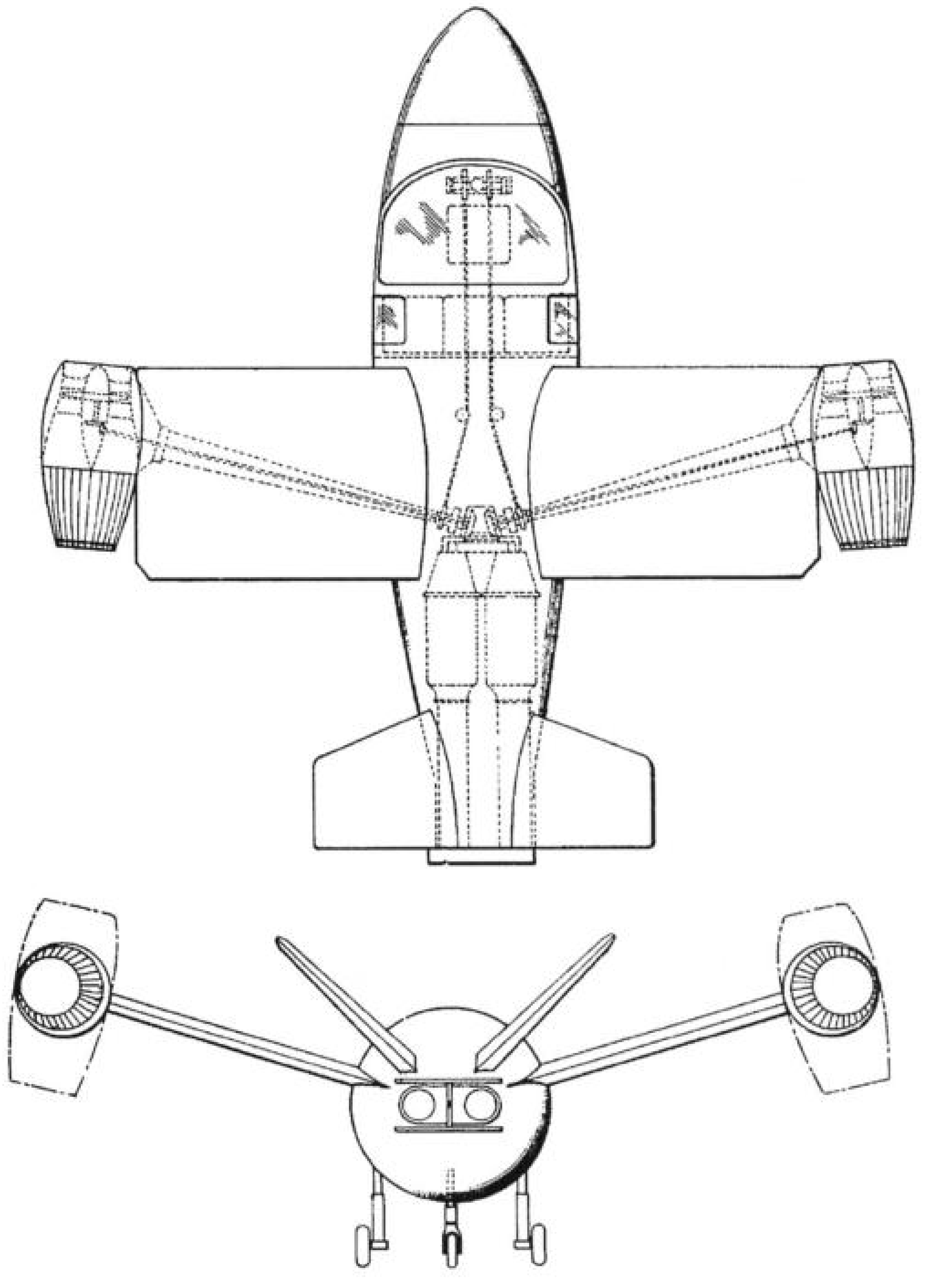
Above right: **Drawings of the Lockheed VTOL ramjet-powered flying disc configured as a passenger-carrying vehicle.** US Patent Office

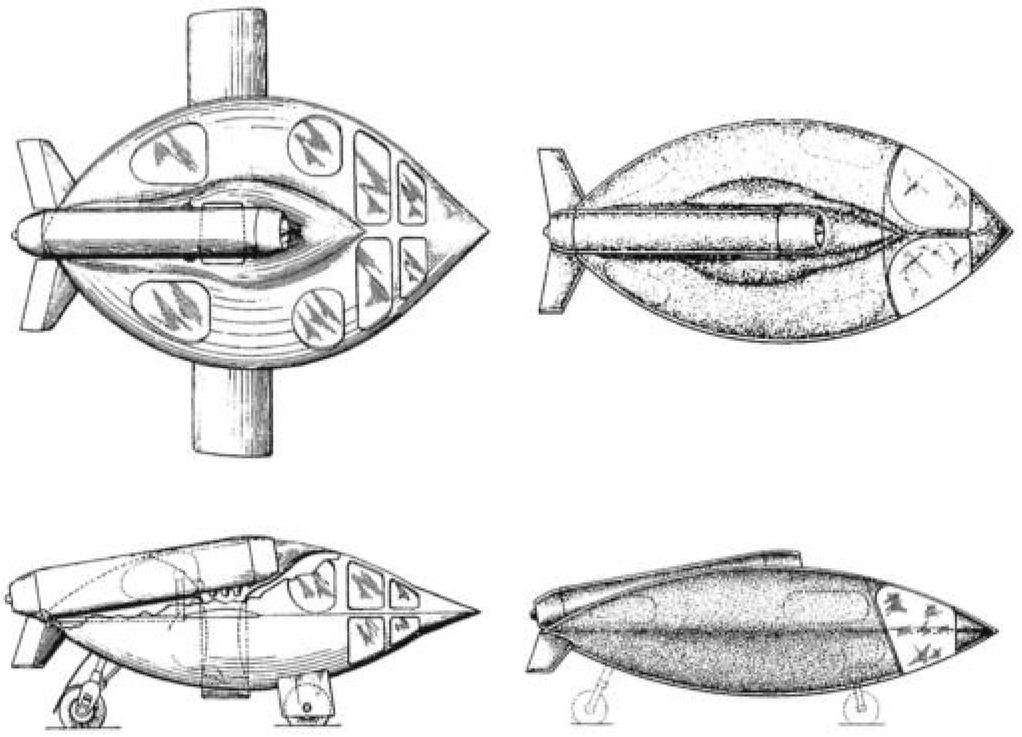
Right: **Detailed drawing of the engine 'island' proposed for the Lockheed VTOL ramjet-powered flying disc.** via Bill Rose



seems more likely that this aircraft was conceived from the outset as a high-altitude long-range USAF nuclear bomber and the civil representation was used to conceal its purpose when two similar US patents were applied for in January 1953 (Ref: 3,066,890 and 3,103,324). Somewhat surprisingly these patents were not confirmed until December 1962 and October 1963, which strongly suggests an initial black project status. There are several vague references in the documentation to military roles for this aircraft, briefly mentioning vehicles with two-man crews and a pilotless variant.







Above left: **One of several small utility VTOL designs produced by Nathan Price.** Lockheed

Above: **A compact VTOL utility aircraft designed in the 1950s by Nathan Price.** Lockheed

Left: **Design evolution of a small oval-shaped utility vehicle, which was produced by Nathan Price during the late 1950s.** Lockheed

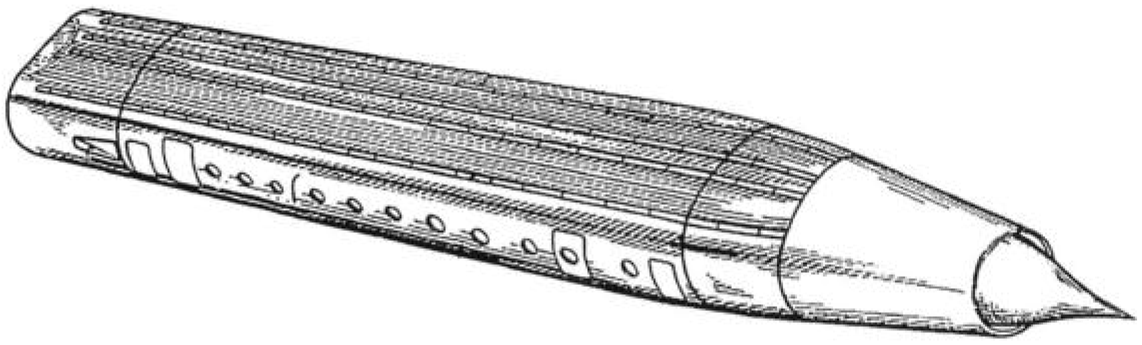
US Patent Office regulations exist for the classification of designs and inventions that are regarded as sensitive to national security and these rules appear to have been applied to this detailed and expensive flying saucer study. Lockheed's lenticular-shaped design was 50ft (15.2m) in diameter and had a gross weight of 55,000 lb (24,950kg). The aircraft would lift off the ground (or touch down) vertically by directing the thrust from its engine island downwards. Having taken off, the saucer's exhaust would be adjusted rearward as it continued to gain altitude. It would climb steadily to 10,000ft (3,048m) at a 10° angle and then increase the angle to 20° until the vehicle exceeded Mach 1 and reached 50,000ft (15,240m). With the propulsive system operating in ramjet mode the flying disc would then reduce its angle of ascent to 10° again, while continuing to accelerate until a maximum speed of Mach 4 had been reached at an altitude of 100,000ft (30,500m). An unrefuelled range of 7,500 miles (12,070km) was considered realistic.

Various fuels were considered, including propane, butane, liquid hydrogen and kerosene. Fuel would be circulated below areas of the aircraft's skin to act as a refrigerant and the suggested material for the surface covering was stainless steel, which during sustained flight at Mach 4 would glow slightly red at 1,140° Fahrenheit (615° Celsius). On the ground four fully retractable struts would support the Lockheed saucer with the option of wheels to improve handling. There was even consideration given to the possibility of making this vehicle amphibious. The level of anticipated performance far exceeded the North American XB-70 Valkyrie developed almost ten years later and it seems a certainty that the Lockheed flying saucer was envisaged as weapon system capable of out-performing any near-future Soviet air defences.

The Skunk Works continued to show an interest in disc and oval-shaped aircraft throughout the 1950s, despite the company's later attempts to distance themselves from flying saucers or closely related designs. Nathan Price also completed a number of very interesting studies for small VTOL utility aircraft, which culminated in a small elliptical design for which he filed a patent application (D183108) in June 1958. This concept was aerodynamically very clean with two short downward-facing tail fins and powered by a turbojet in a housing above and behind the cockpit. The cockpit, which might house between two and four occupants, was fully integrated with the forward fuselage. The aircraft's retractable undercarriage took the

Lockheed wingless aircraft designed by Nathan Price. This unusual flying cigar configuration may have been developed from the central section of the VTOL flying disc. US Patent Office

Lockheed wingless VTOL aircraft designed by Nathan C Price. The first study was completed in 1957 and underwent a significant revision by the following year with Price making a number of aerodynamic improvements and changes to the proposed propulsion system. US Patent Office



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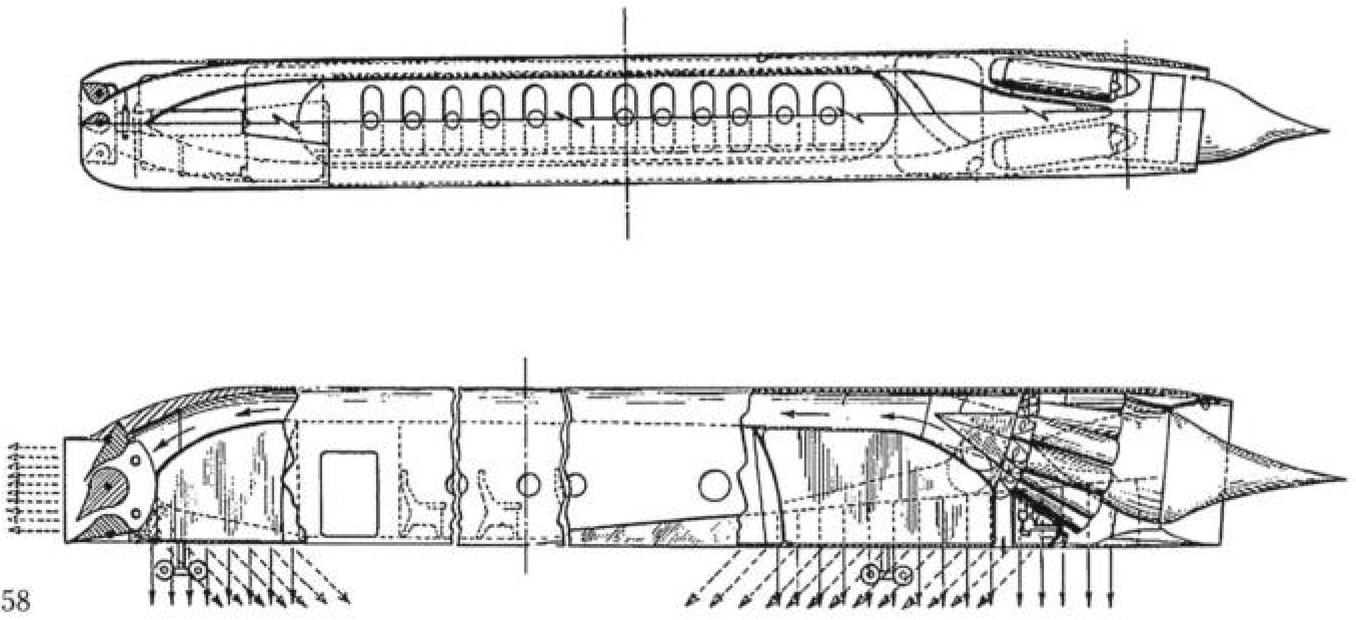

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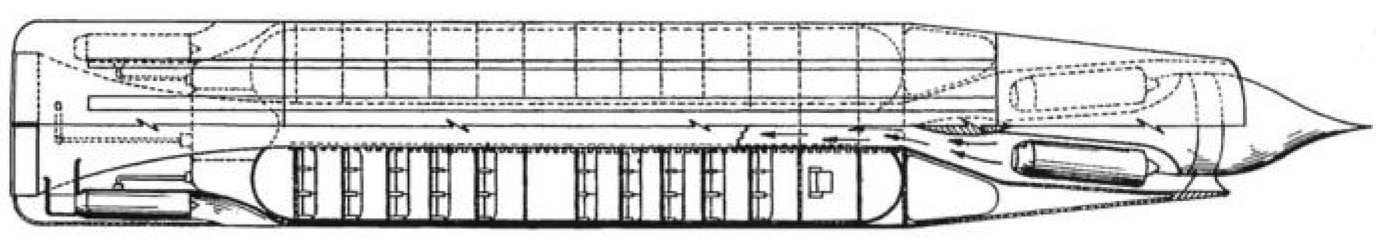

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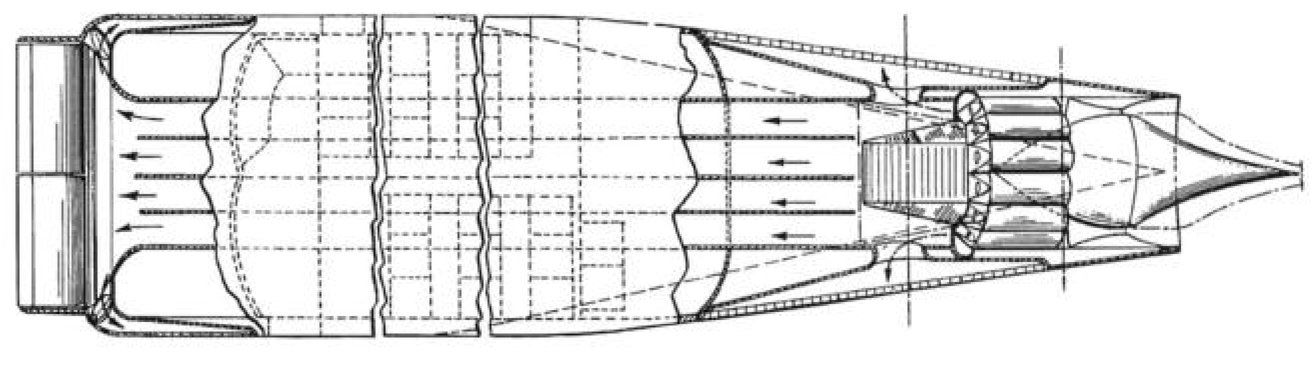


1958

form of two forward wheels and a tailwheel. Exactly the purpose Price had in mind for this vehicle is unknown and it did not appear to be designed for VTOL operation. Perhaps it was viewed as a general utility aircraft.

Whether or not any of these circular and oval-shaped aircraft were prototyped and flown from Groom Dry Lake remains unknown, but it seems certain that some of these studies progressed to wind tunnel testing.

Lockheed Skunk Works Flying Cigar Studies

Four years after completing his first set of designs for a Mach 4 flying saucer, Lockheed's senior engineer Nathan C Price was putting the finishing touches to an even more extraordinary-looking concept that seems so unusual it remains hard to take seriously on first inspection. Price had produced detailed plans to build an aircraft with no wings or tail assembly and no visible cockpit. Capable of VTOL operation and high supersonic speed, this design was filed as a US Patent on 13th August 1957, but not listed as a Patent (3,148,848) until 15th September 1964. It is tempting to suggest that Price took a long hard look at his ramjet-powered flying saucer design and wondered what would happen if it was stripped right down to the central duct.

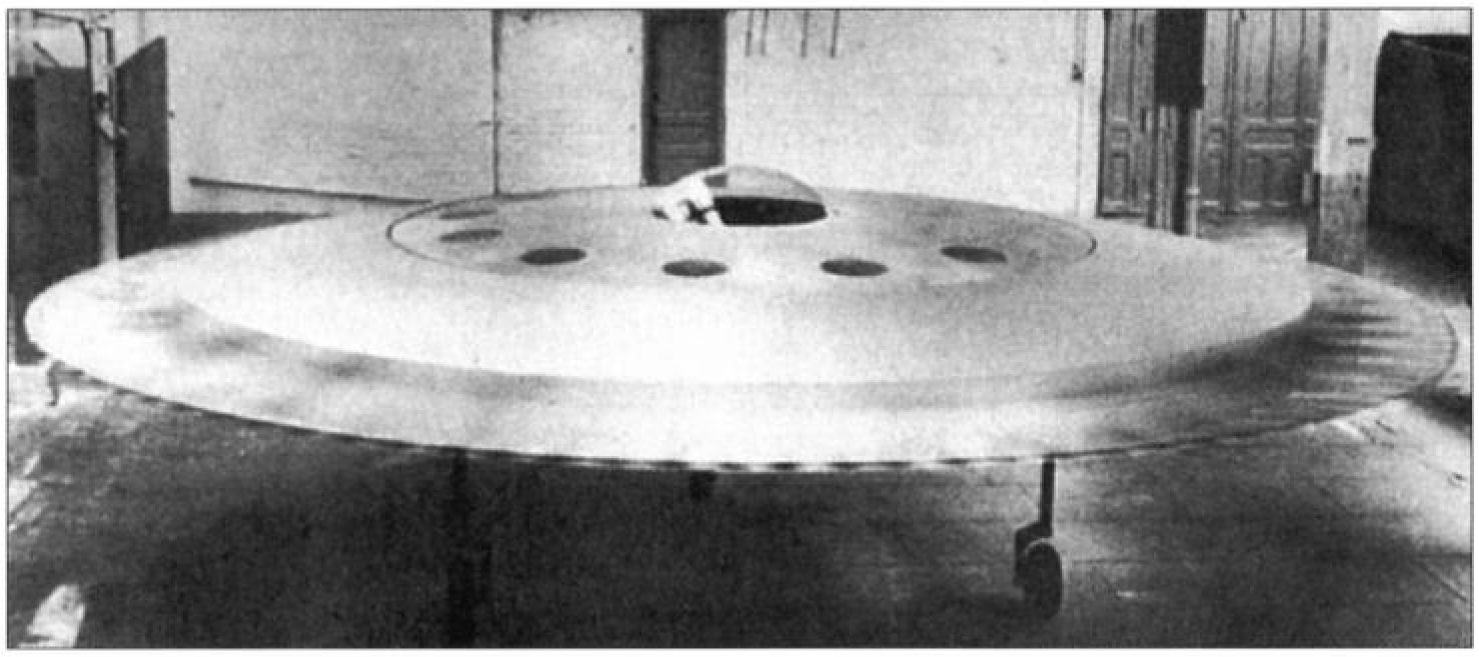
Amongst the technical specifications for this design, Price mentions that certain features could be exploited in crescent- or circular-shaped aircraft. However, the basic idea was to build a ramjet-powered missile-like aircraft that was capable of VTOL and operation at low speeds. A cluster of turbojets would provide basic low-speed propulsion and during VTOL operations exhaust gases would be channelled through upper vents to provide lift using the Coanda Effect. In supersonic level flight the turbojets would be shut down and the aircraft would be propelled by ramjet power. A cruising speed of Mach 3 to 4 was anticipated, with a ceiling of perhaps 90-100,000ft (27-30,000m), and long range was discussed, suggesting an intercontinental capability. With no visible control surfaces, directional movement in level flight was to be achieved by vectored thrust through a series of louvres.

Price envisaged a highly automated aircraft, flown by inertial guidance combined with programmed radar, although he acknowledged that a crew would be needed to handle emergencies. This concept was released as a passenger-carrying aircraft and, while there might have been some commercial interest in such a design, it seems very likely that a military application was the starting point. In 1958 Price made a number of technical upgrades to his original concept, producing a more aerodynamic fuselage and revising the VTOL ascent and descent efflux nozzle system. He also acknowledged the likelihood of serious noise problems inside the aircraft and proposed measures to reduce this. It is probable that wind tunnel models were tested and some of the research found its way into the development of guided weapons. Anticipated weights and dimensions are unknown.

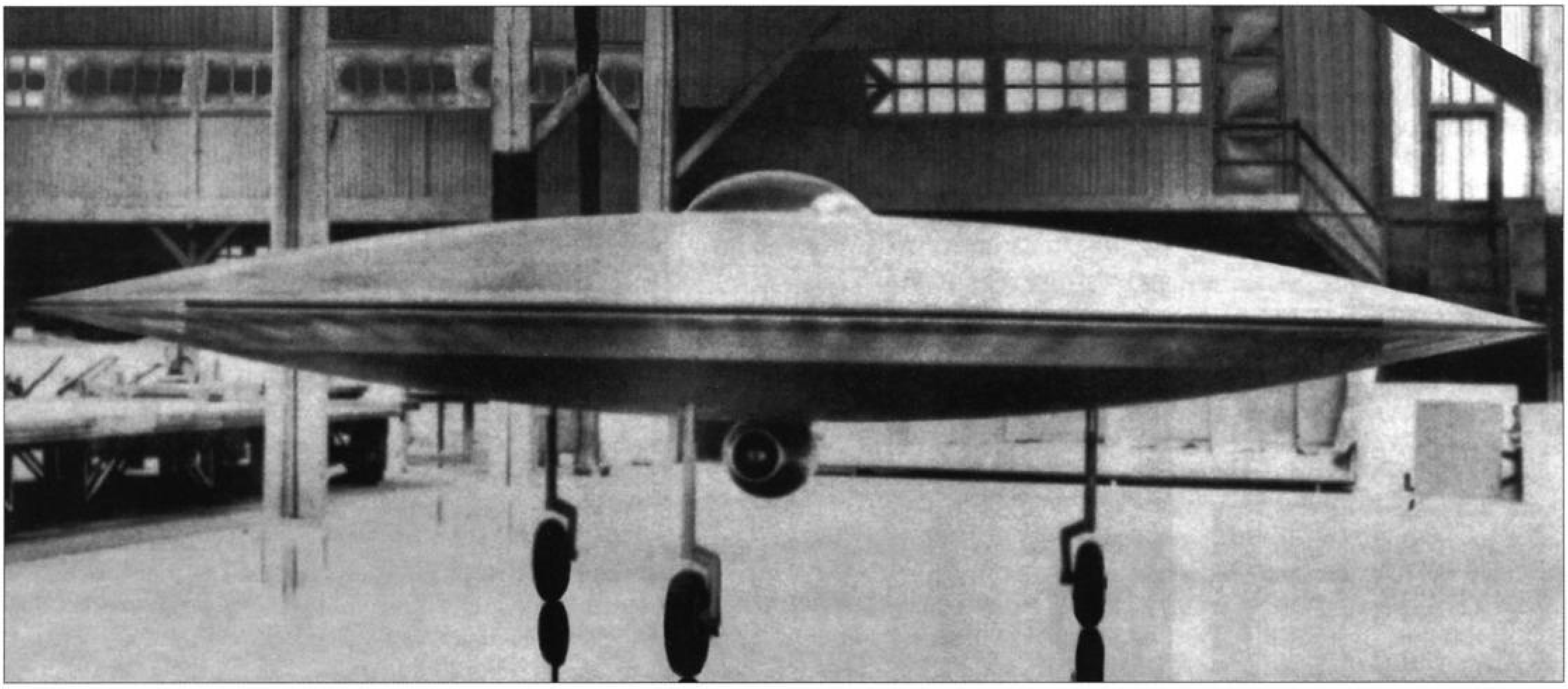
Couzinet's Flying Saucer

René Alexandre Arthur Couzinet was born in 1904 at Saint-Martin-des-Noyers in the Vendée region of France. He was one of aviation's true pioneers, but would only receive the kind of recognition he deserved several decades after his death. Today, his name appears in France on postage stamps and roads, while a college and rural airport have been named Couzinet in his honour.

René Couzinet with a model of the RC.360 Aerodyne. via Bill Rose



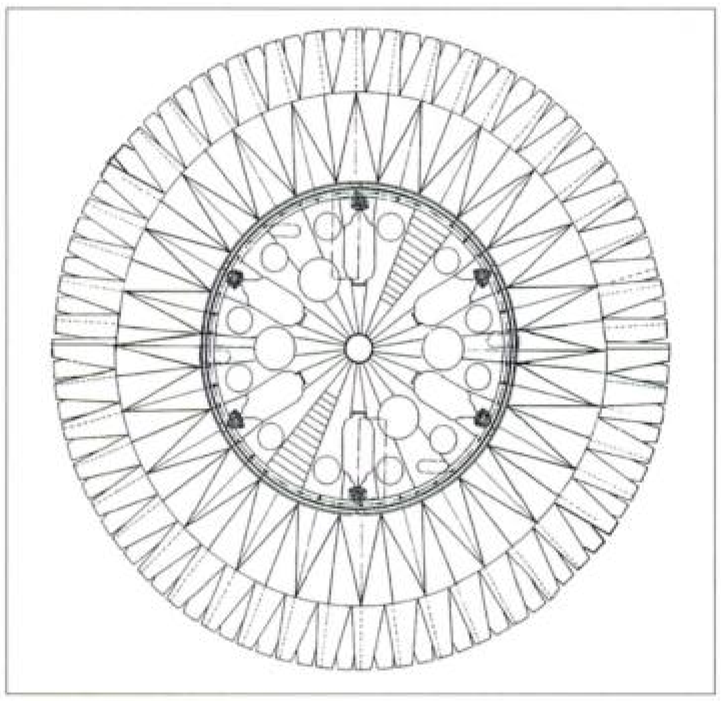
View of the Couzinet Aerodyne scale model. via Bill Rose

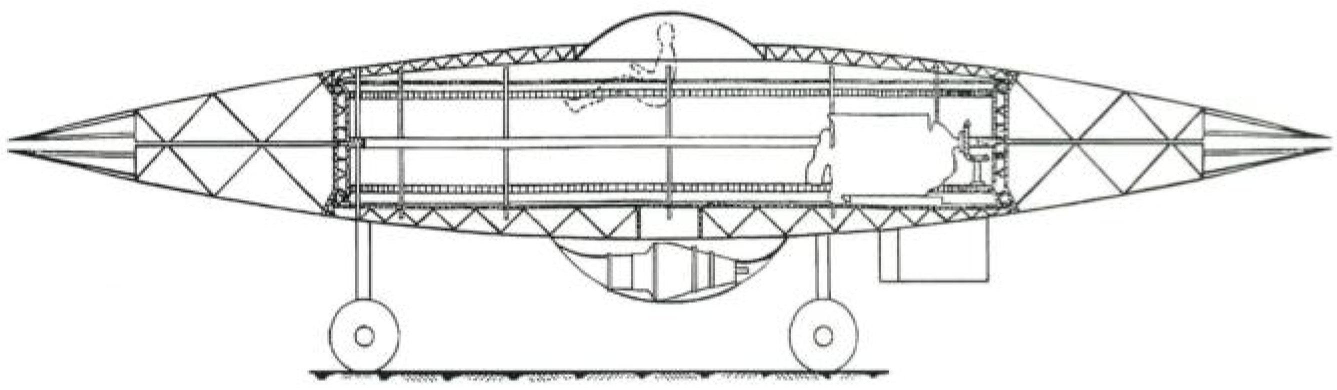


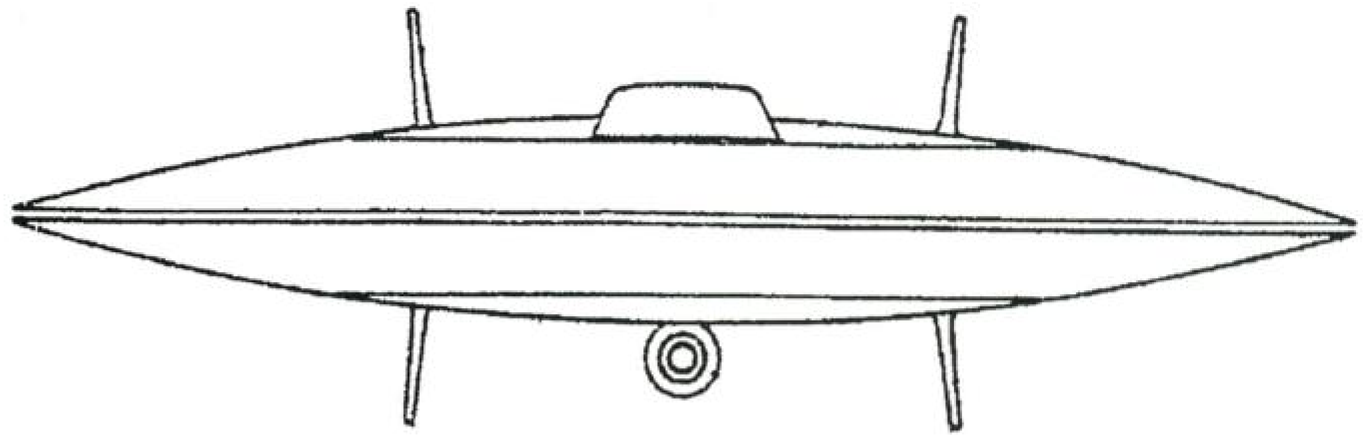
Couzinet Aerodyne scale model. via Bill Rose

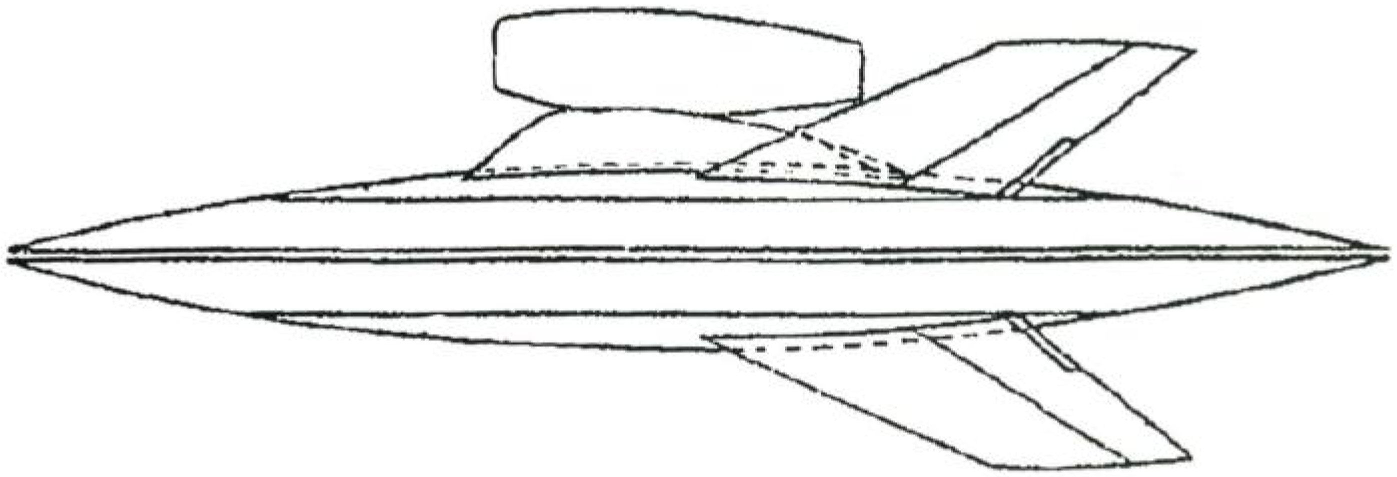
As a child, Couzinet was fascinated by the way birds flew and he had filed several aviation patents, including plans for a helicopter, by the time he joined the Higher School of Aeronautics in 1924. In 1925 Couzinet enrolled in the Air Force as a junior officer and, following the historic trans-Atlantic Lindbergh flight of 1927, he was assigned to the development of a new aircraft capable of intercontinental journeys. This led to the eventual construction of a three-engined aircraft called 'The Rainbow', which carried Couzinet, his close friend Jean Mermoz and five crewmembers on the first successful double crossing of the South Atlantic in 1933. During December 1936 Jean Mermoz was killed in a Latécoère seaplane and René Couzinet was deeply affected by this, although he eventually married Mermoz's widow Gilberte Chazottes in 1939.

At the start of World War Two, Couzinet and his wife relocated to Brazil. Having entered into a fifteen-year contract with the Brazilian Government, Couzinet taught aeronautics at the Brazilian Air force Training School and Brazil's President Gétulio Vargas appointed him as director of national aircraft production. Construction was undertaken at a small facility near the training school, which was staffed by thirty-five French engineers who had worked on Couzinet's earlier









Above: **Couzinet Aerodyne scale model, planform drawing.** via Bill Rose

Top right: **A cross-section drawing of the Couzinet scale demonstration model.** via Bill Rose

Right: **An unretouched drawing of the proposed R.360 Aerodyne.** US Patent Office

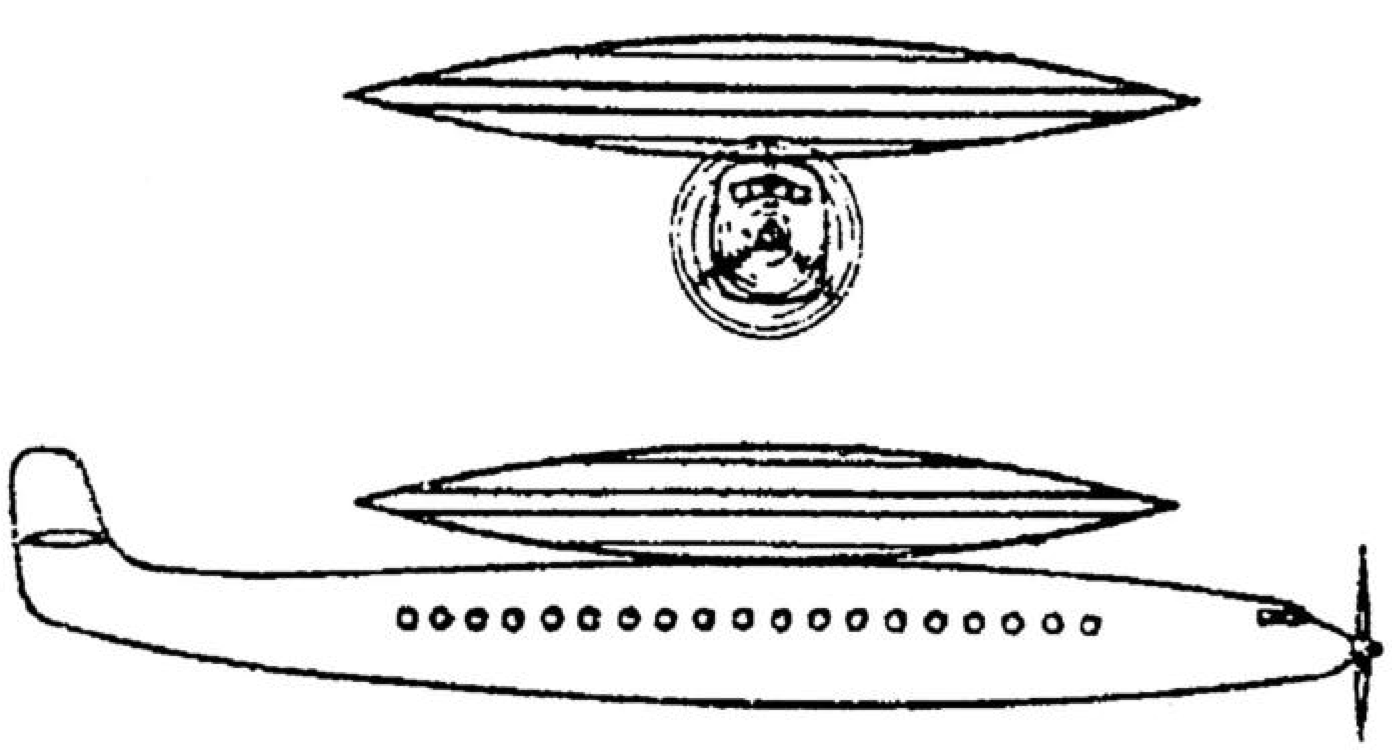
Lower right: **Drawing showing side view of the Couzinet RC.360 Aerodyne.** US Patent Office

designs. However, it was no longer possible to buy aviation components from France, which was now under German occupation, so Couzinet tried to obtain engines and parts from America. Unfortunately the supply stopped when America entered the war and there were further problems when he was banned from entering America. Then Couzinet managed to upset the Free French! For the remainder of the War Couzinet's company manufactured gas generators and engineering equipment, although he still found time to design new aircraft and develop a small seaplane.

Couzinet was clearly something of a rebel and fought a long-term campaign against members of the French aeronautical establishment, which he ultimately lost. After the war he began to consider the concept of hydrofoils and then a VTOL flying disc, spurred along by media interest in flying saucers. Having re-established himself in France, Couzinet began work on a VTOL Aerodyne flying disc during the early 1950s and filed patents in France during May 1955. Known as the RC.360, Couzinet built a 3/5th-scale model of his design at the Levallois-Perret factory.

Completed by autumn 1955, the Aerodyne model was unveiled to the World's press. It was a 29ft (8.84m) diameter (Silver Bug-sized) aircraft supported on a tricycle undercarriage, with a centrally positioned cockpit that was covered by a dome shaped transparency. The system of propulsion was expected to be three 180hp (134kW) piston engines driving two contra-rotating discs fitted with ninety-seven peripheral blades. This was planned to provide enough lift for full VTOL operation and create gyroscopic stability, while a Palas gas turbine carried in a pod on the underside of the craft would be used for forward flight. Flight control would be achieved with three control surfaces and by swivelling the jet engine. While Couzinet insisted that his Aerodyne was only an engineering mock-up, it was reported that the vehicle was largely functional. Two Lycoming internal combustion engines were installed and these were used to drive the rotors at 80rpm during static test runs.

Wooden scale model of the RC.360 flying saucer built for René Couzinet. via Bill Rose



An original drawing by René Couzinet for a conventional airliner with circular wing.
US Patent Office

The full-sized RC.360 aerodyne was under development at Couzinet's factory at Roche-sur-Yon and this promised good subsonic performance in level flight. Wind tunnel testing of models was carried out, but exactly how much progress was made with the full-sized airframe remains unknown. Nevertheless, there were American reports published in early 1956 that indicated an initial test flight was scheduled for April of that year. The RC.360 had a span of 44ft 7in (13.6m) and a lifting surface area of 645.6ft^2 (60.0m^2). It worked on essentially the same principle as the smaller model, but used six Lycoming engines instead of three. In addition, there would be fifty adjustable vanes instead of forty-eight and four stabilising fins. The aircraft's main forward propulsion was provided by a licence-built Armstrong Siddeley Viper turbojet delivering 1,639 lb (7.2kN) of thrust and, fully fuelled, the aircraft had a take-off weight of 27,700 lb (12,565kg).

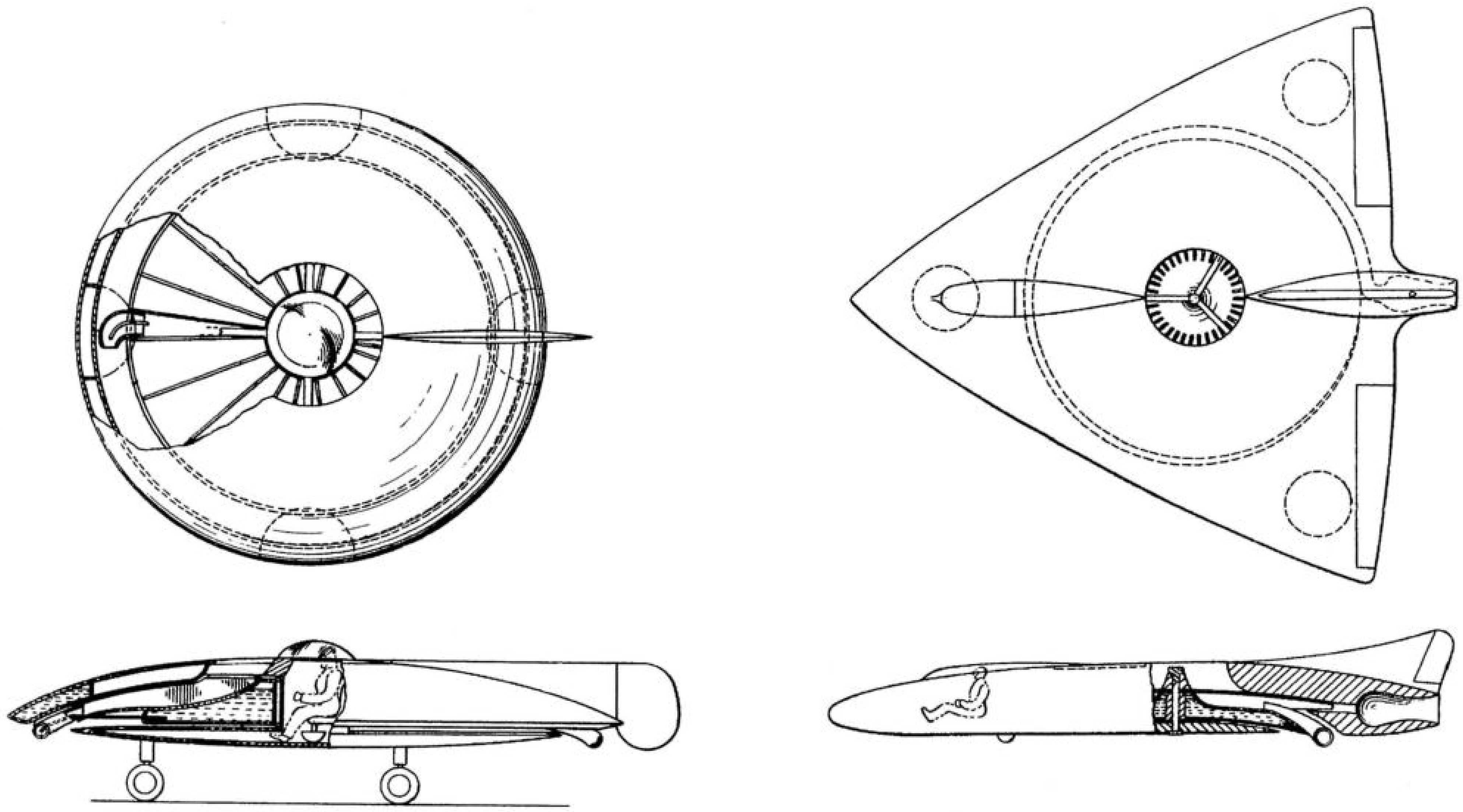
Beyond pure research, it remains unclear what role Couzinet envisaged for the Aerodyne, which was unlikely to provide the flexibility of a conventional helicopter and would not have had the high-speed performance of a military jet. However, within the documents relating to this design, Couzinet discusses the vulnerability of airfields to attack, which strongly suggests that a military purpose was envisaged from the outset. Further details in the same documents show another rather strange concept, comprising a conventional aircraft fuselage with a disc mounted above. It is hard to see the thinking behind this somewhat clumsy proposal.

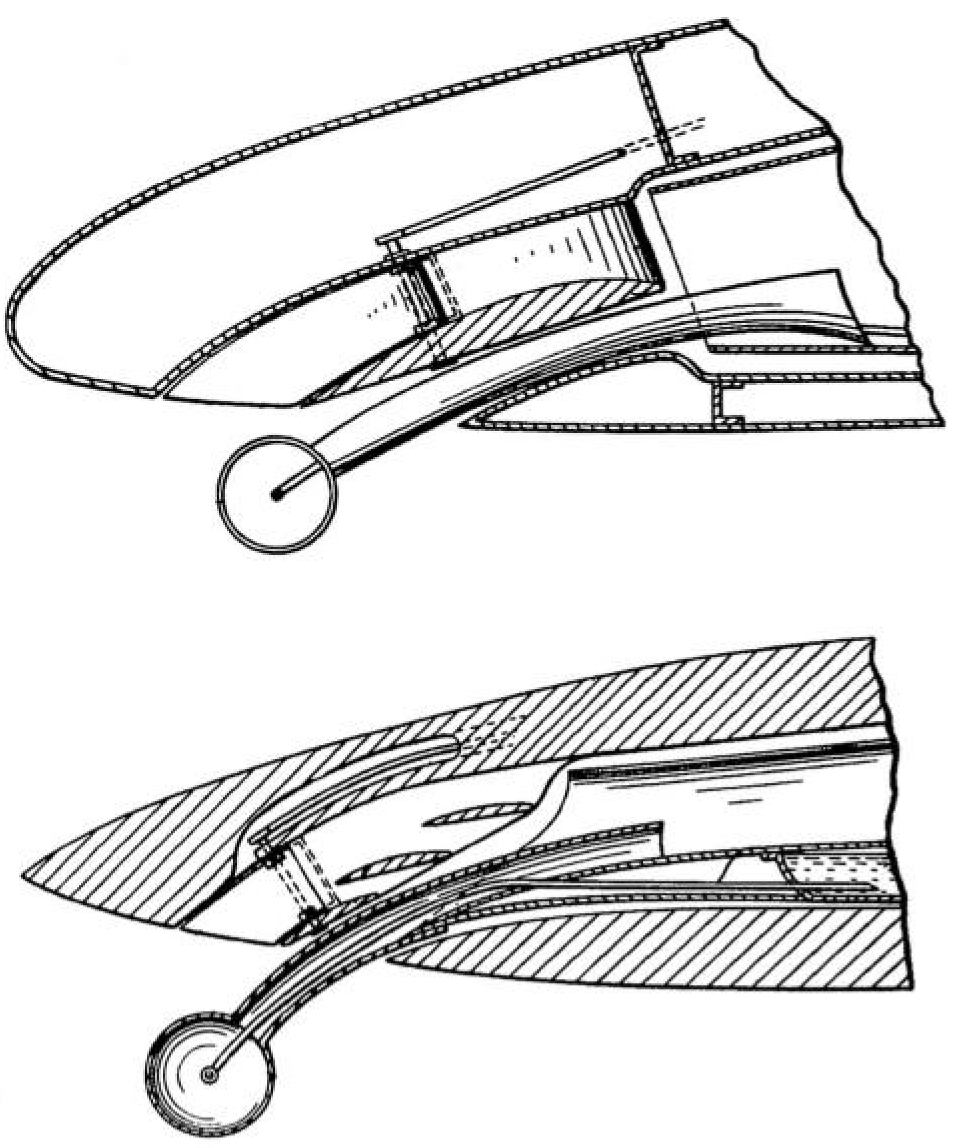
After the initial interest in the RC.360 project died down, Couzinet was unable to raise enough money to complete the full-sized prototype. Disillusioned by the complete lack of interest in his project, René Couzinet and his wife Gilberte committed suicide in their apartment on Sunday 16th December 1956. It was a tragic end for one of the world's great pioneers and a truly innovative aircraft designer. The scale mock-up of Couzinet's Aerodyne vanished without a trace and there seems to be some genuine mystery about what happened to it, although it was probably broken up for scrap.

Wibault's VTOL Concepts

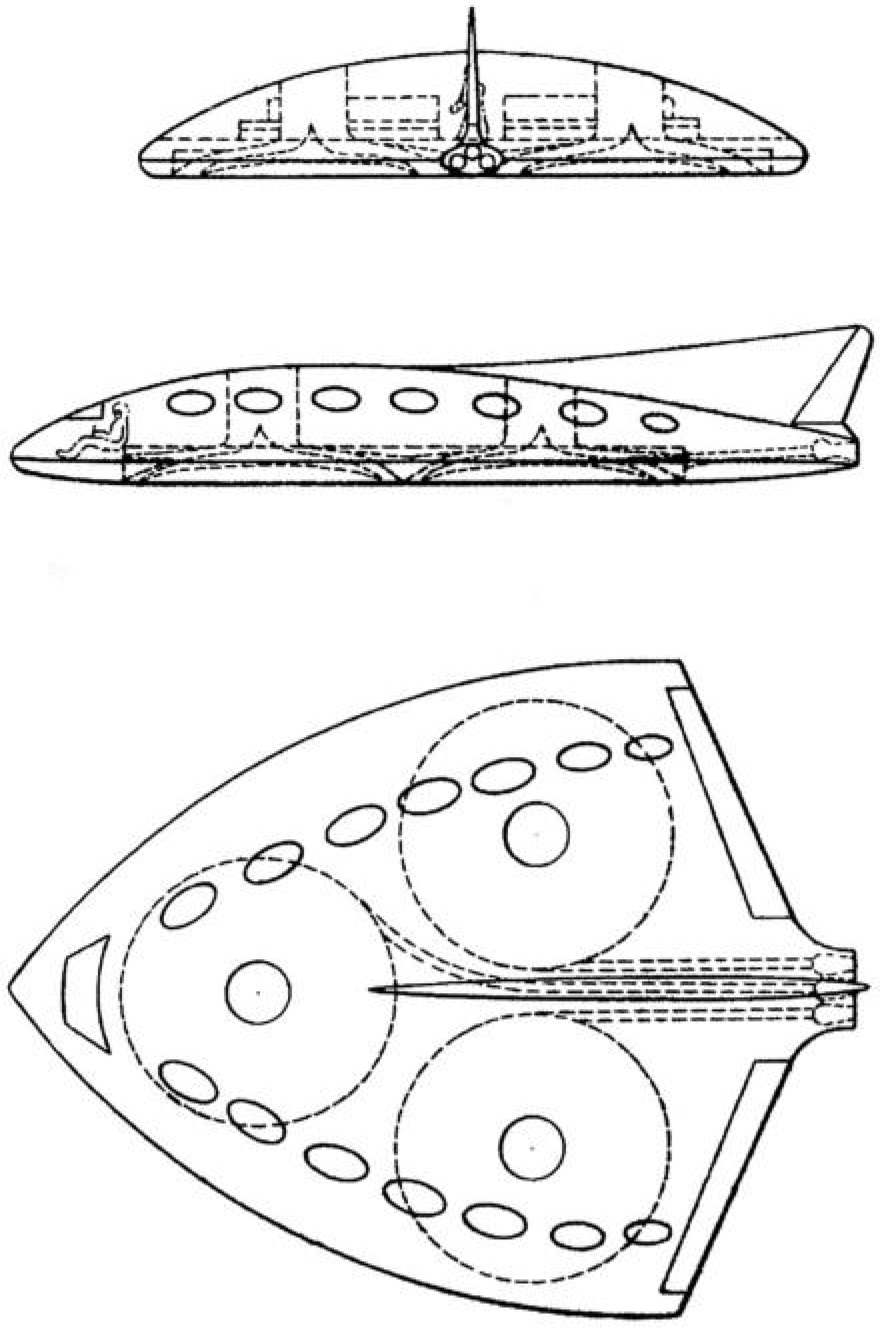
During the early Cold War years there was considerable French military interest in VTOL aircraft. This led to some very unusual projects such as the SNECMA tail-sitters, which can be traced back to German wartime research.

Drawings of two different Wibault VTOL aircraft designs from the early 1950s. Both use the same internal rotor propulsion system. via Bill Rose





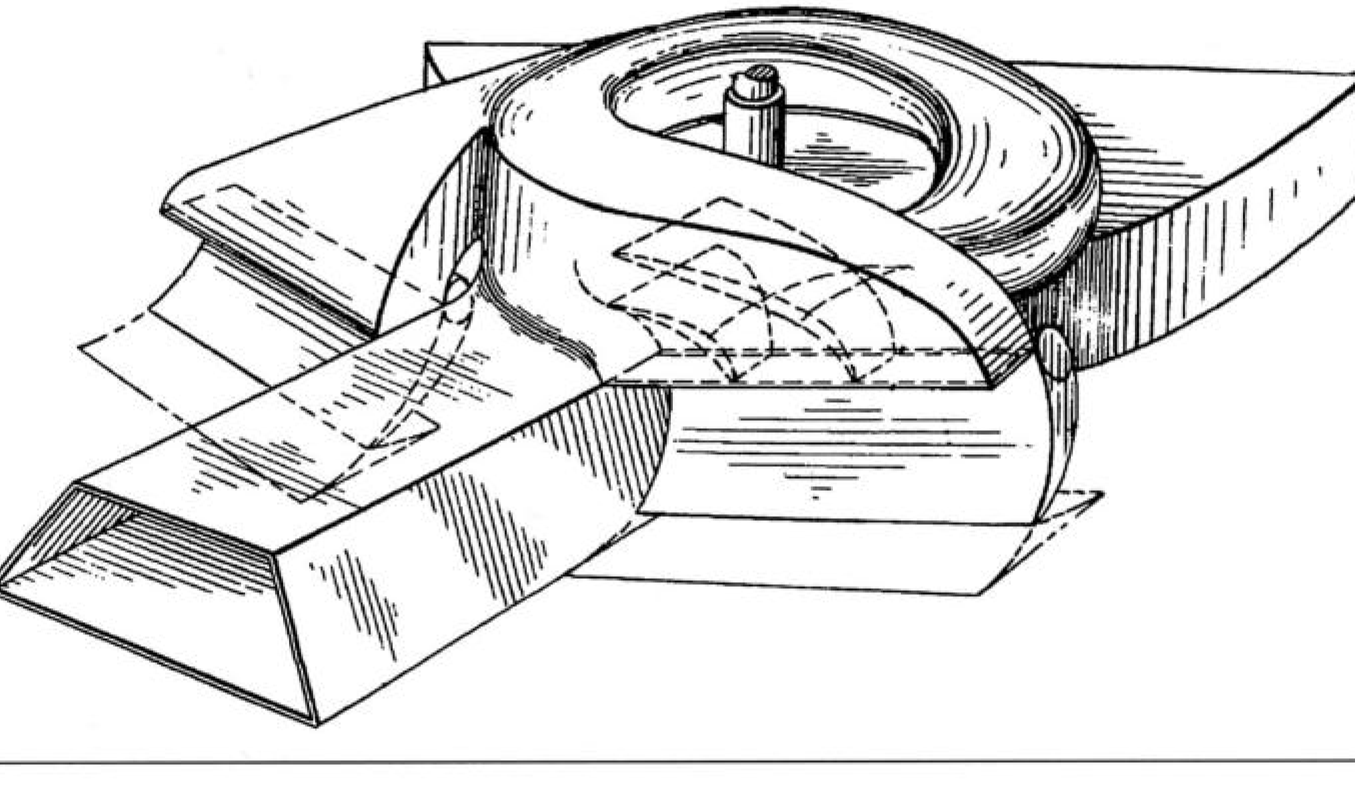
Above: **Cross-section of the Wibault tip-driven rotor design for his VTOL aircraft concepts.** via Bill Rose



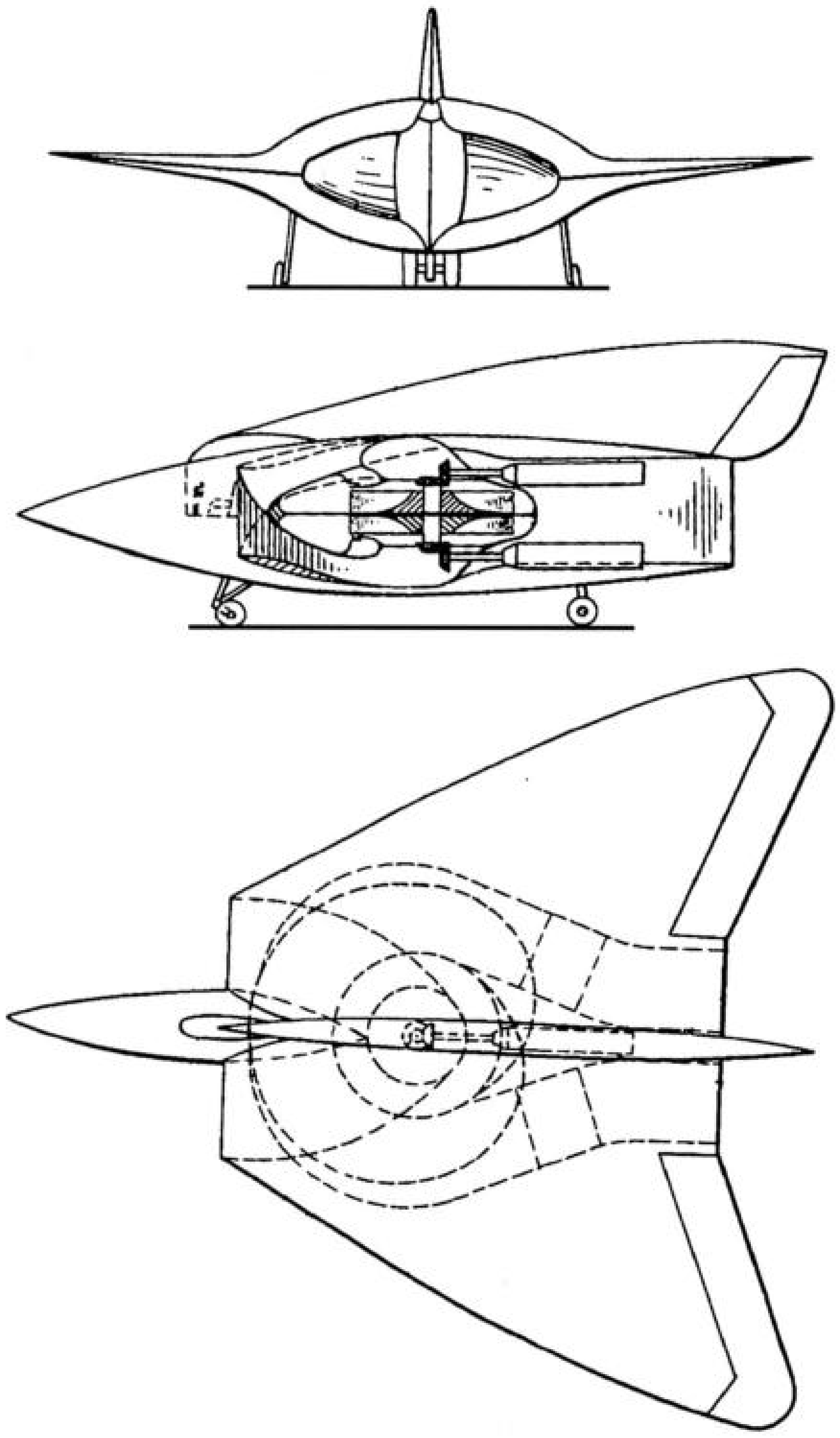
Right: **Michel Wibault's design for a three-rotor VTOL transport aircraft.** via Bill Rose

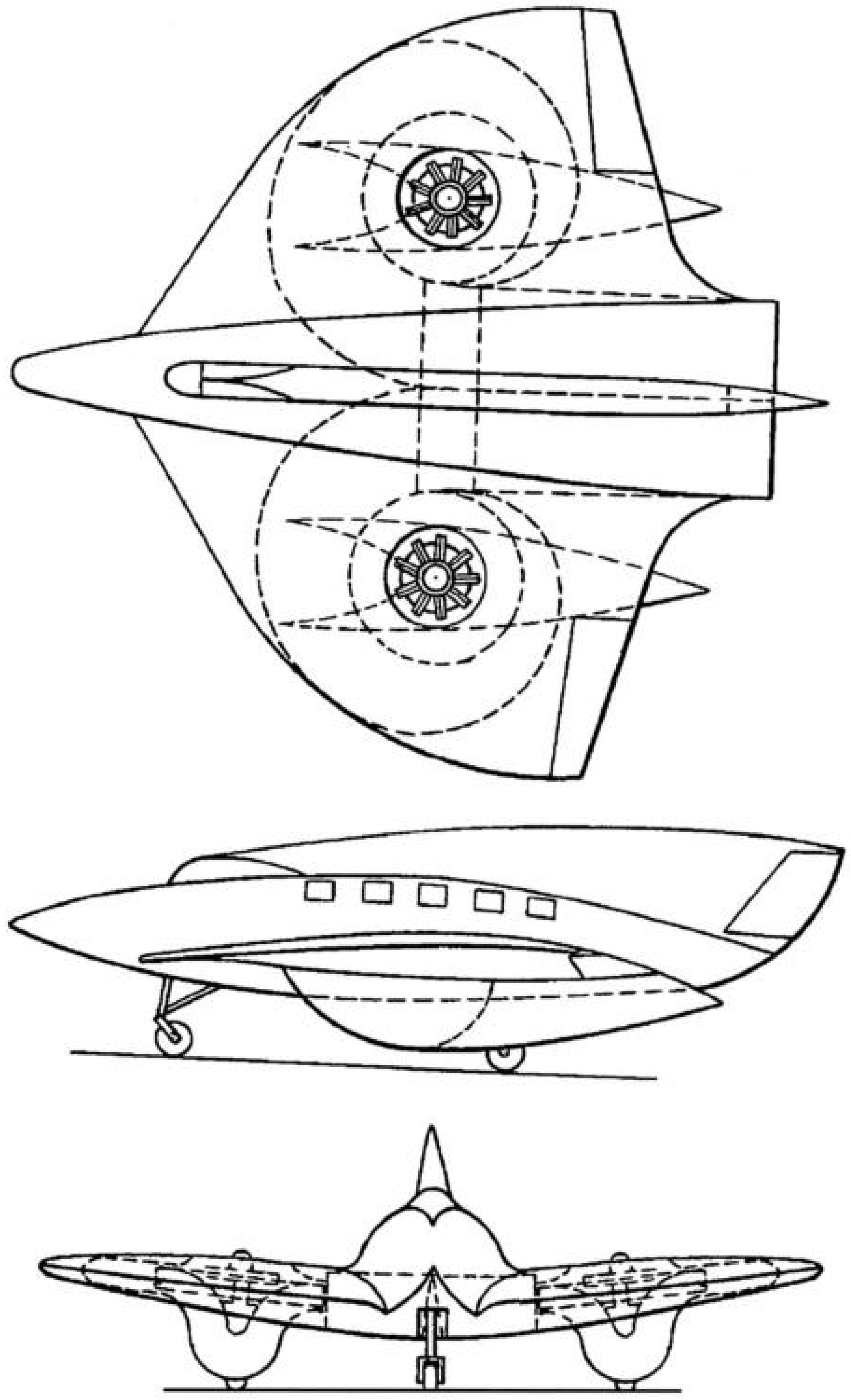
Michel Henri Wibault was a well-known Paris-based designer with a number of aircraft to his credit and a strong interest in VTOL technology. In 1950 Wibault began working on a disc-shaped aircraft that he called the Gyropter. It utilised an enclosed rotor system that would provide a full VTOL and hover capability while also allowing high-speed level flight. Air would be drawn in around the upper stator and driven downwards, while the enclosed rotor was protected from the influences of airflow during horizontal flight. The rotor would be driven by several tip-mounted jet engines or ramjets protruding from the fuselage, with fuel (and possibly air) fed along the hollow rotor arm. This might seem rather a complicated arrangement, but tip-driven rotors eliminate problems associated with torque. Forward flight would be achieved by adjustment of the airflow from the rotor and supplementary jet engines seemed a certainty.

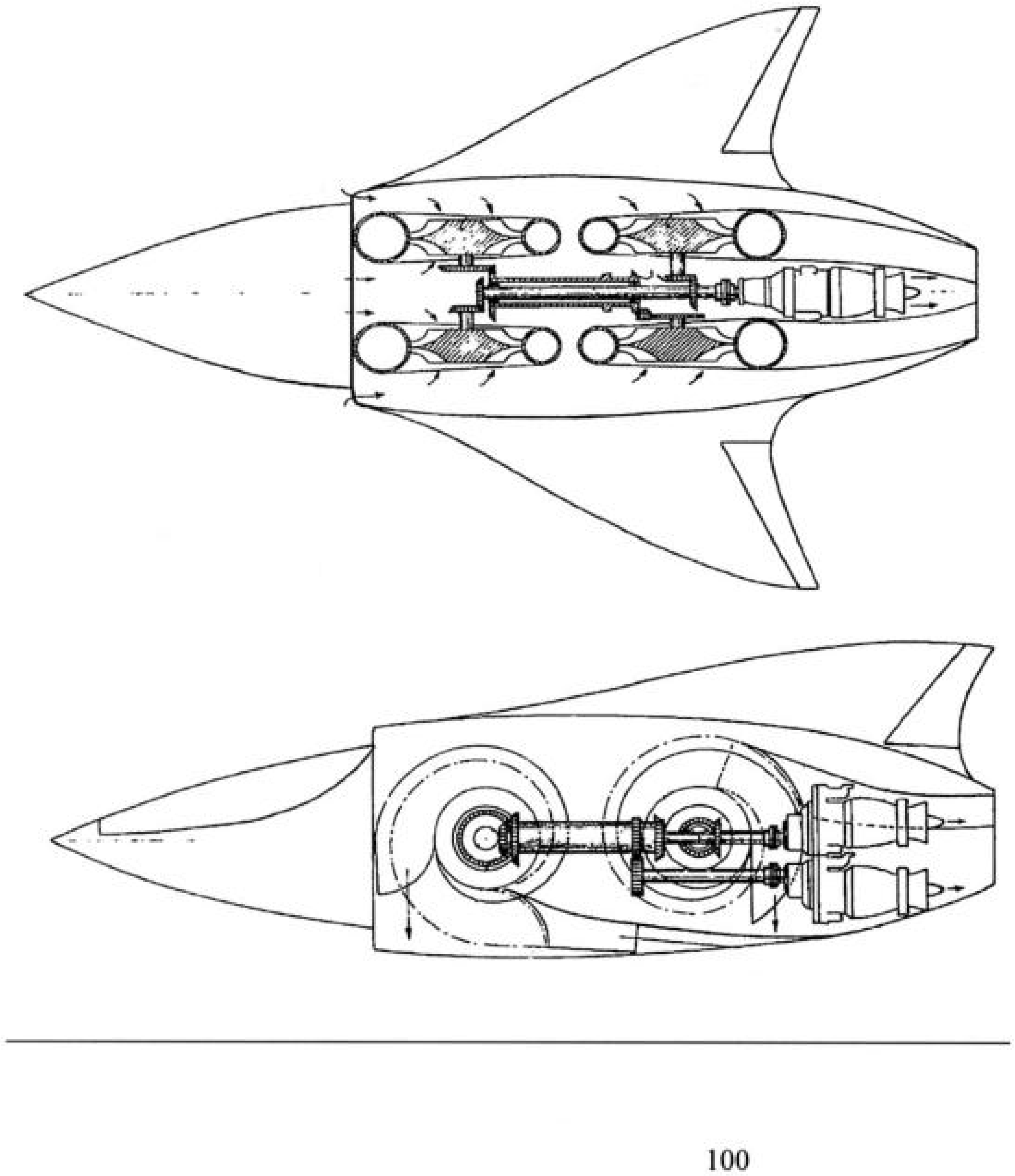
The initial design was for a one-man vehicle, with the cockpit located in the centre of the main hub and covered by a dome-shaped transparency. The Gyropter would have four ballast tanks located around the rim of the disc for controlling trim and an upper fin and rudder. Wibault also expected the rotor to provide a degree of gyroscopic stability. No details of dimensions or weights were provided, but an initial prototype would have been similar in both respects to the Avro Canada Project Y2 research craft and fitted with a fully retractable three- or four-strut undercarriage. The first design in this series was completed in mid-1953 along with larger versions of the Gyropter using multiple enclosed rotors. Wibault also evolved the aircraft's disc planform into more of a spade-shaped delta and the final concept from this series showed a sleek VTOL transport aircraft that still looks very contemporary with three lift rotors and two jet engines at the rear, fed with air from all three rotors.

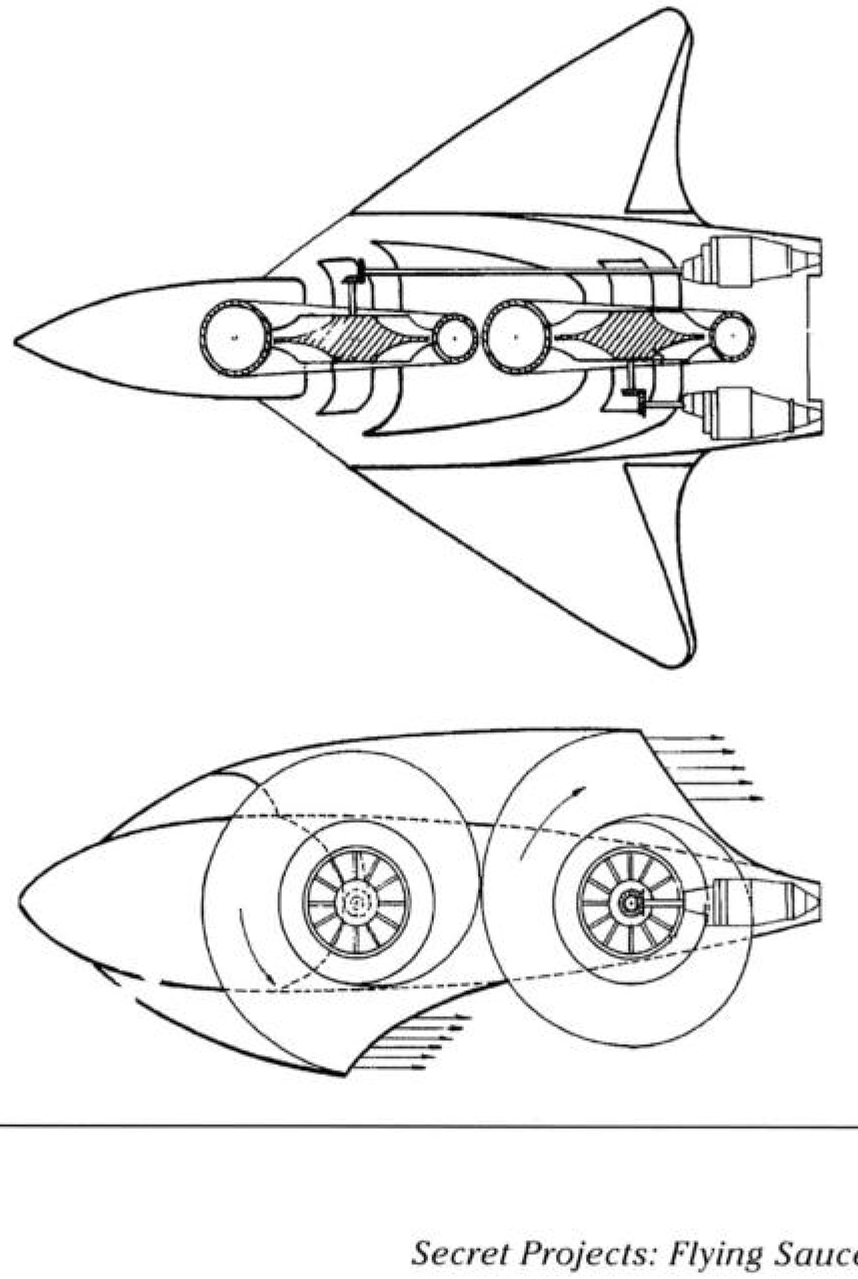


An early design by Michel Wibault for a blower unit capable of providing aircraft with VTOL performance. via Bill Rose









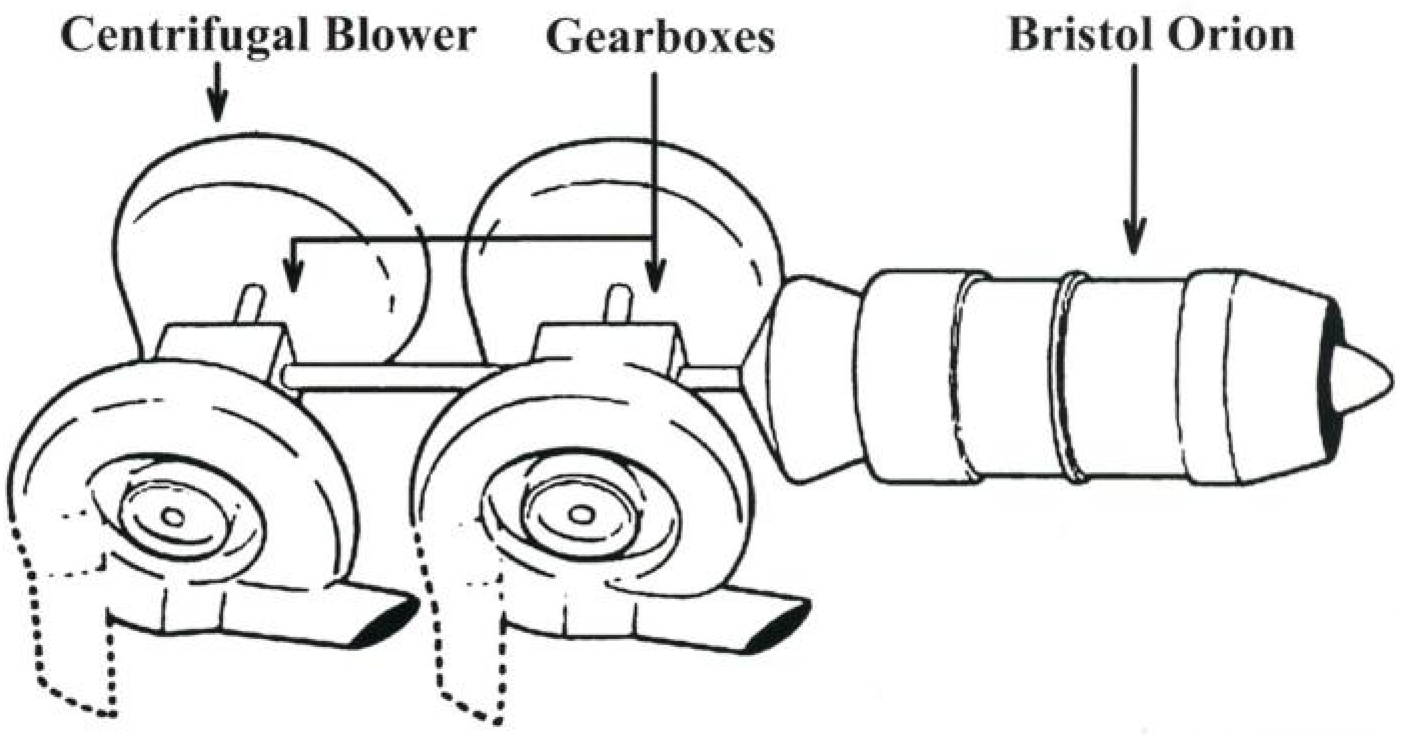
Opposite page:

Top left: **One of Michel Wibault's proposals for a VTOL delta-winged military aircraft with complex ducted fan propulsion system using contra-rotating blowers driven by two gas turbines.** via Bill Rose

Top right: **A complicated design for a VTOL aircraft, produced by Michel Wibault in 1954 using vertically positioned turboprop engines to drive large blower units in the wings.** via Bill Rose

Bottom left: **Wibault VTOL fighter concept, using four centrifugal blowers coupled to two gas turbines for lift and forward flight.** via Bill Rose

Bottom right: **The fighter aircraft concept by Michel Wibault uses two centrally located blowers shaft-coupled to two gas turbines for lift and forward flight.**



This page:

Right: **Michel Wibault's 1956 design for a propulsive system to provide his Gyroptère aircraft design with a VTOL capability. Driven by a British built Orion turboshaft engine, the four snail-shaped blowers would rotate to provide lift and level flight. This design would eventually lead to the very sophisticated Pegasus engine used in the Harrier.** via Bill Rose

Below: **AV-8B Harrier II. The advanced propulsive technology used in this aircraft can be traced directly back to research carried out by French designer Michel Wibault.** US Marine Corps

By the mid-1950s Wibault had changed direction having produced a new aircraft design with a more conventional shape. It was still referred to as the Gyropter but utilised a new type of propulsive blower system. Wibault envisaged a single-seat single-engine VTOL strike fighter that could be used to deliver tactical nuclear weapons from an improvised dispersal site. The propulsion system comprised four blowers located around the aircraft's centre of gravity powered by a Bristol BE.25 Orion turboshaft engine producing 8,000hp (5,970kW). Each of these blowers would rotate to produce downward or horizontal thrust.

In 1955 Wibault went to the French government to ask for development funding but the application was rejected. He then approached the NATO Mutual Weapons Development Program (MWDP) Office in Paris, who forwarded his design studies to Theodore von Karman for review. The documents were finally passed to Stanley Hooker at Bristol Aero Engines in England and he was sufficiently impressed by Wibault's work to assign a small development team, comprising Gordon Lewis, Pierre Young, and Neville Quinn, to study the ideas in detail. Realising the basic concept could be substantially improved by directly channelling the engine's exhaust via swivelling ducts, the team set about building an engine called the BE.48.

The engine design based on an Orion soon evolved into the BE.52 and then this was

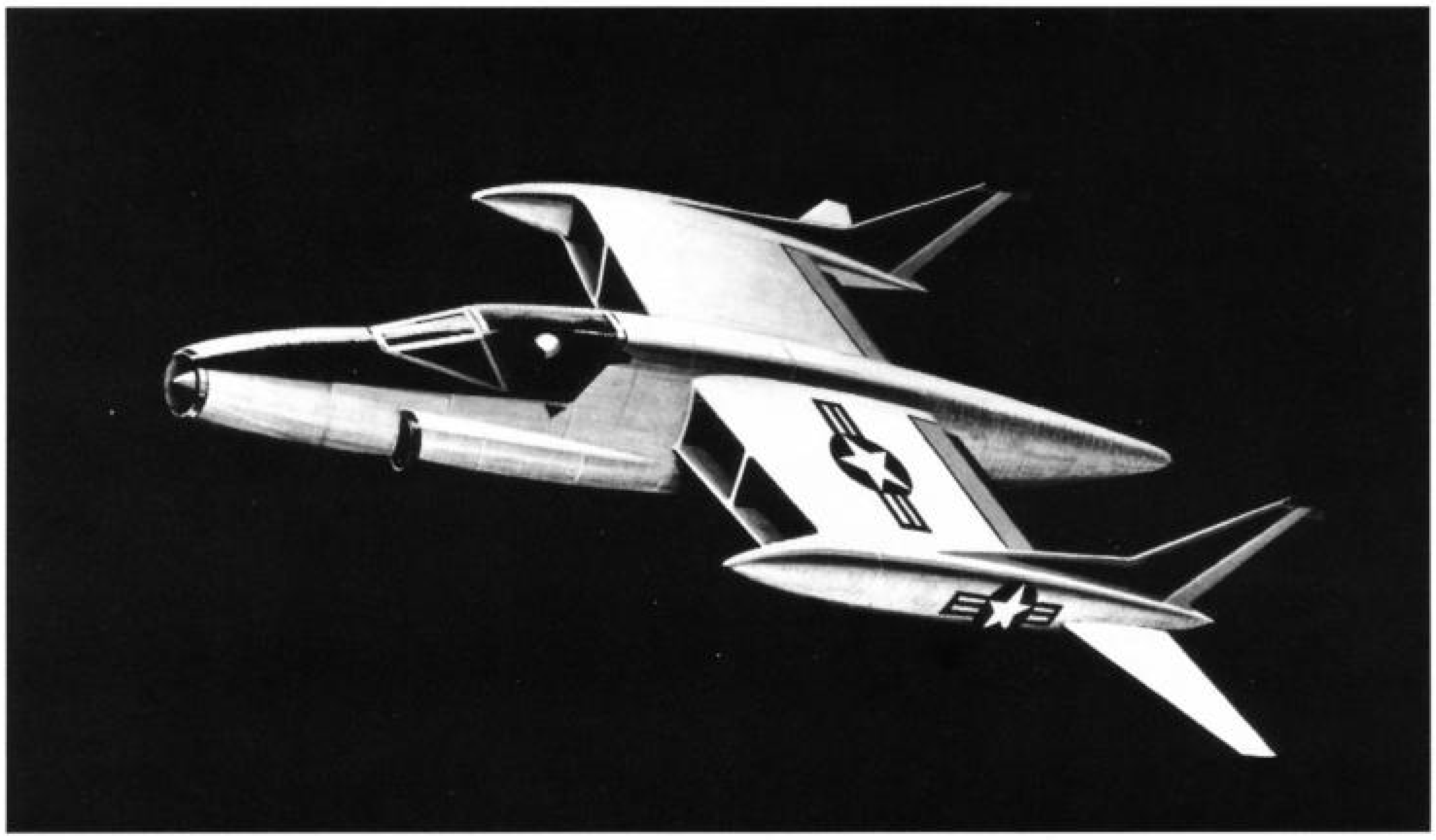
replaced by the BE.53, which was built around an Orpheus turbojet with a larger compressor fan. Wibault was now working for Bristol as a consultant engineer and an initial patent for the BE.53 was applied for on 12th January 1957. Rather sadly, Wibault died soon after becoming the joint patent holder with Gordon Lewis but Bristol Aero Engines now had a new type of engine, albeit with no aircraft to carry it. However Sydney Camm, the chief designer at Hawker Aircraft, took an immediate interest in the project, which eventually brought the creation of a prototype called the Hawker P.1127. This finally led to the world's most successful VTOL combat aircraft – the Harrier.

ADAM

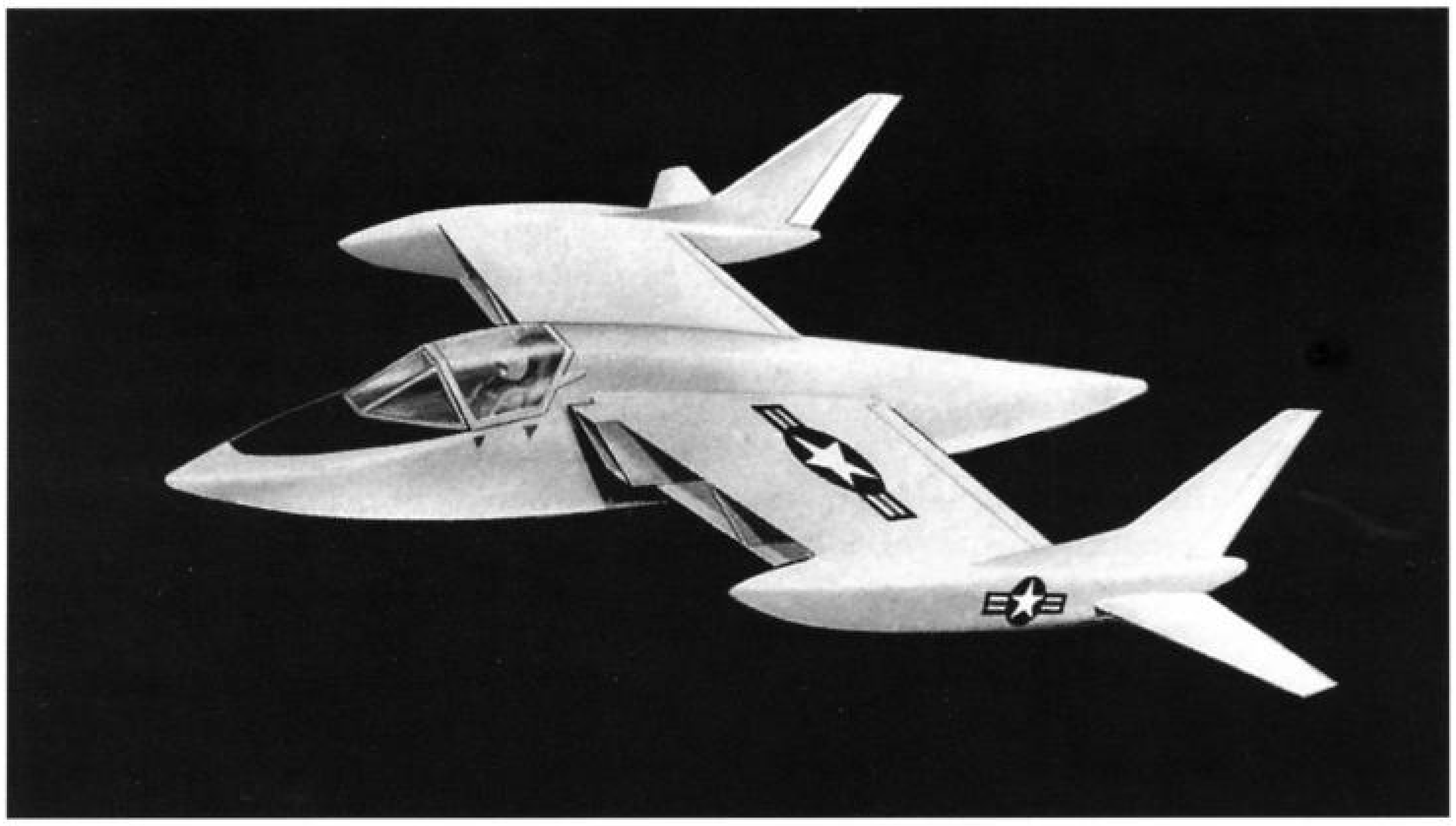
In 1958 Vought and several other contractors began to study methods of diverting exhaust gas from one or two jet engines downwards, through a series of shutters, with the aim of developing a working VTOL system for jet aircraft. The studies seemed promising and, during January 1963, Vought received sufficient funding from the USAF and US Army to explore the possible application of this technology to new combat aircraft. Although the company was reforming as Ling-Temco-Vought, the project was considered sufficiently important to be maintained and the Dallas Design Office believed it would be possible to construct a military VTOL aircraft that could hover for brief periods; it would also possess good transonic or even supersonic performance in level flight.

The ducted flow system was known as Air Deflection And Modulation (ADAM) and Vought began to fund studies that would lead towards an initial proof-of-concept demonstrator that carried the company designation V-460; a supersonic option was also discussed that was called the V-480. In many ways the ADAM concept amounted to a follow-on from Zimmerman's Flying Pancakes, drawing on most of the original aviation requirements but taking full advantage of advances in propulsive technology. Company executives within Ling-Temco-Vought felt certain that the V-460 would also appeal to the US Navy and a campaign of promotion and lobbying began.

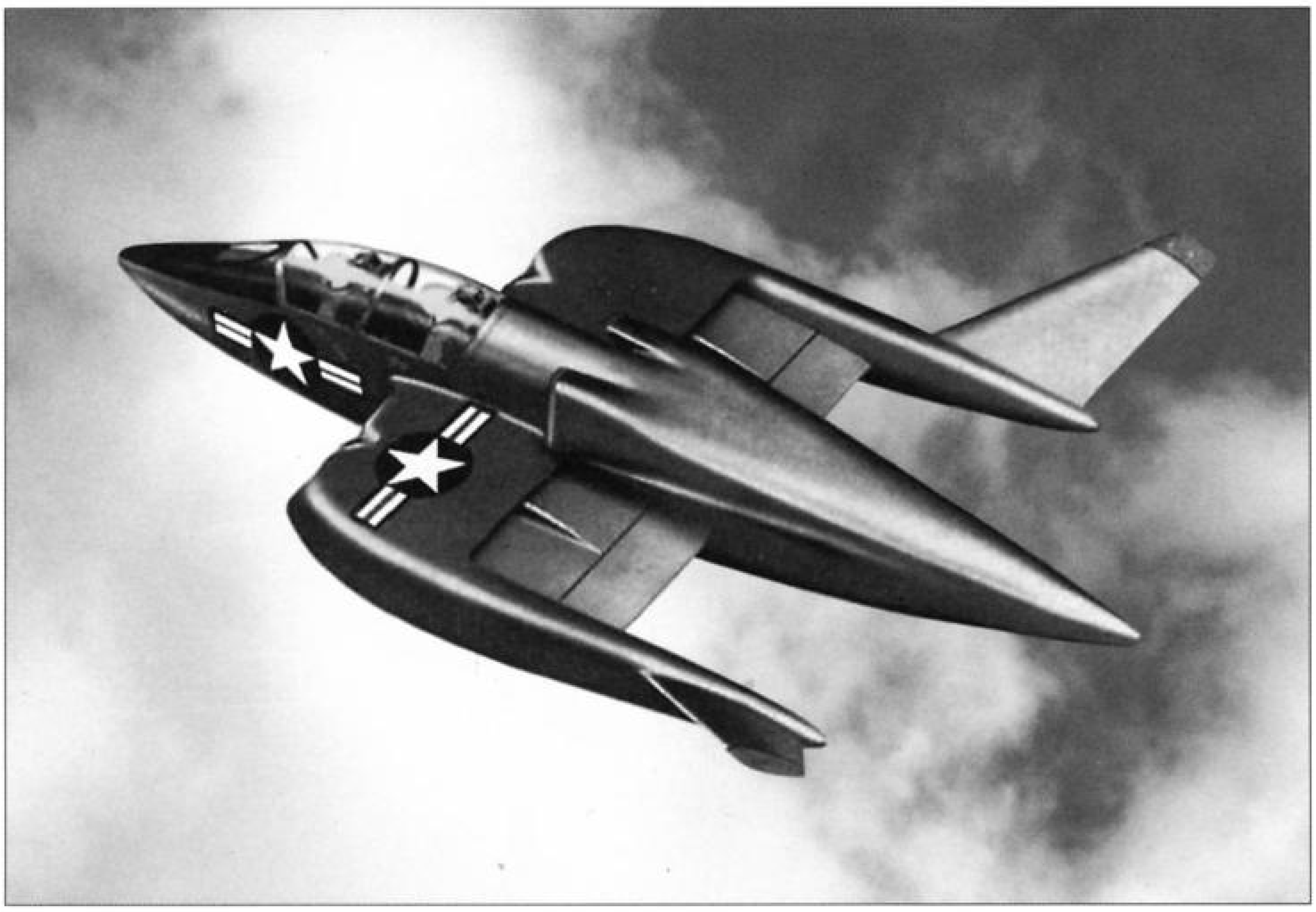
Two significantly more advanced proposals emerged from the design office, known as



An early design study for the single-seat Vought ADAM demonstrator using a nose air intake. Ling-Temco-Vought

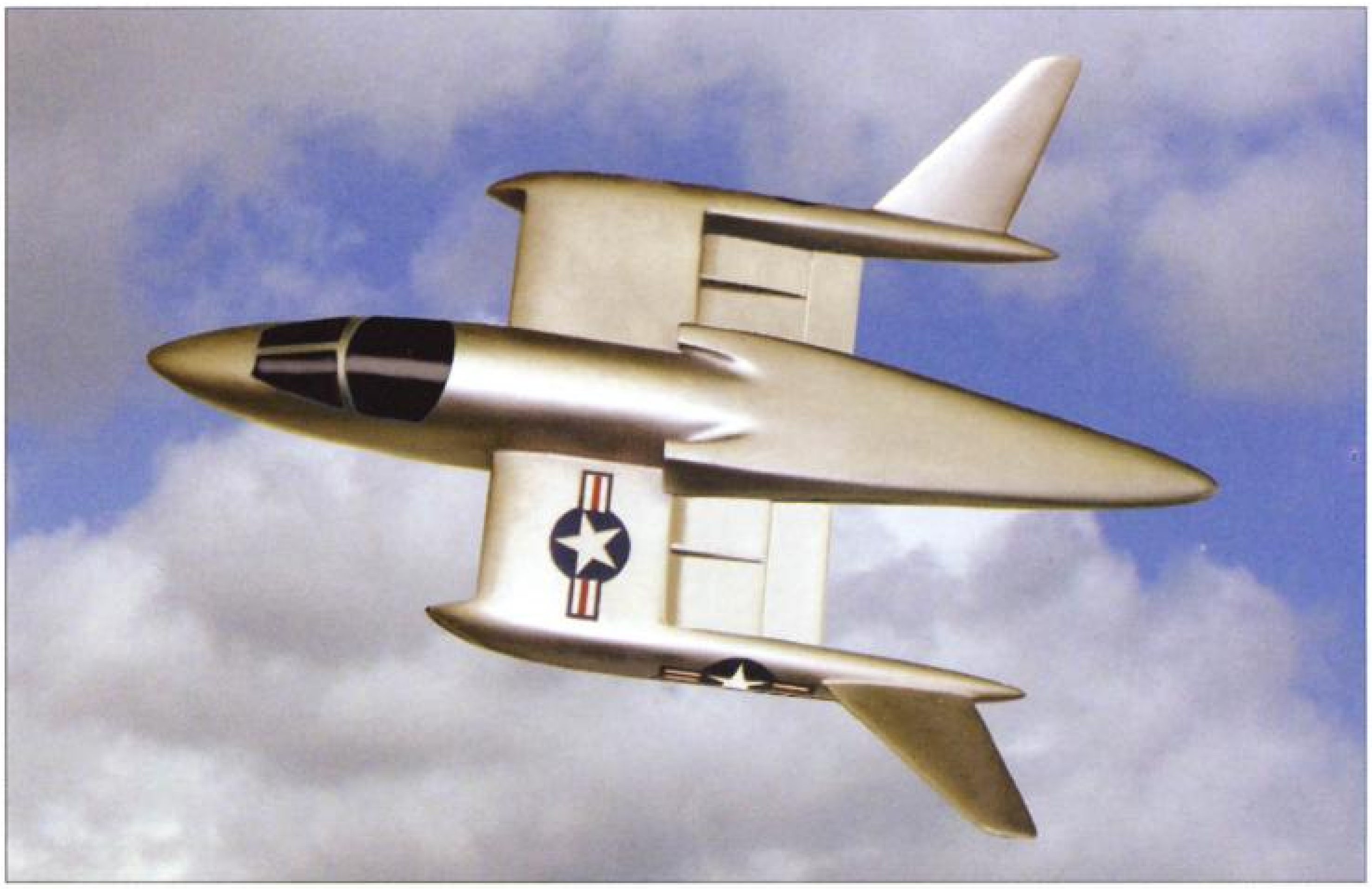


Early concept drawing for the Vought V-460 single-seat ADAM demonstrator. Ling-Temco-Vought

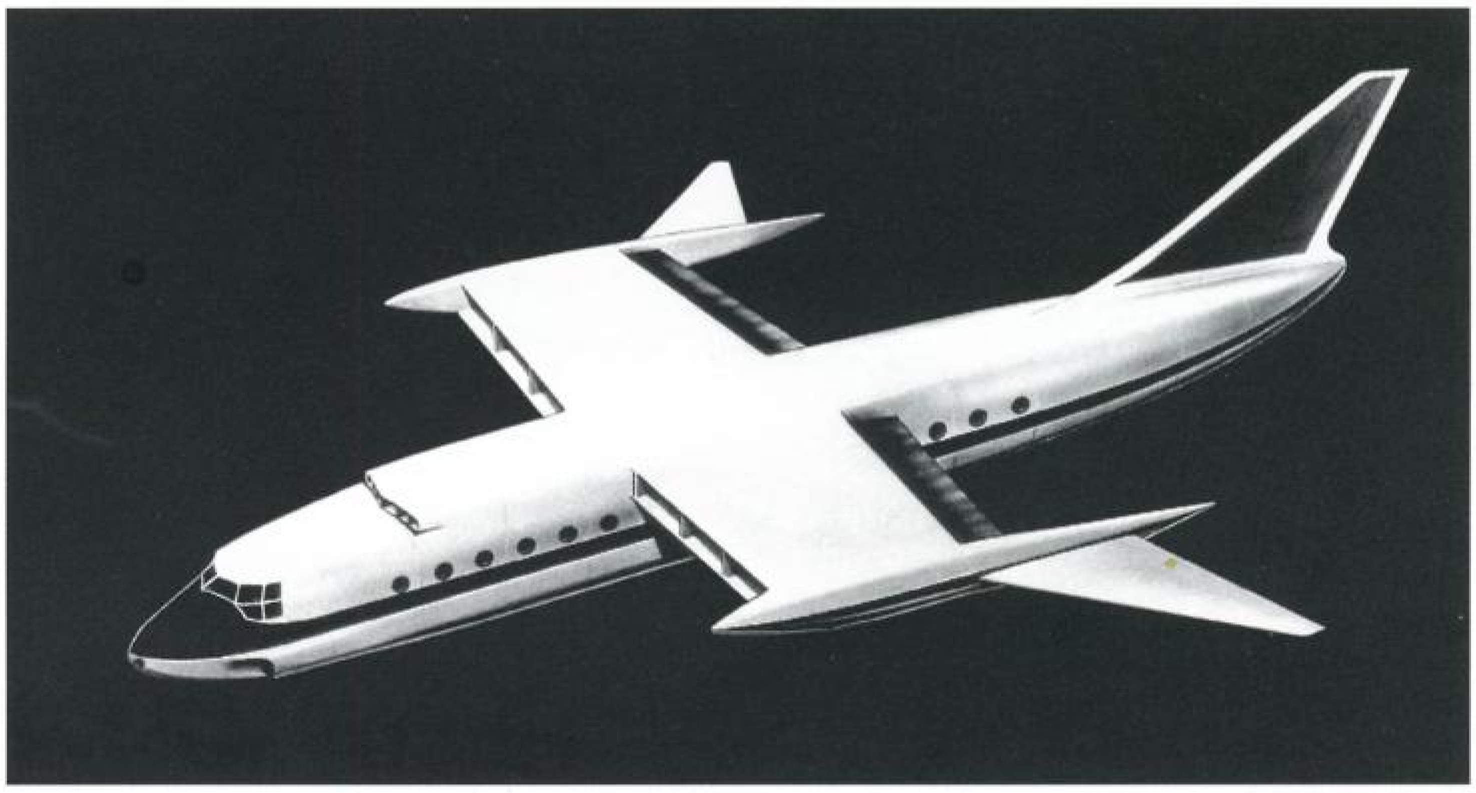


Two-seat Vought V-485 ADAM 11 aircraft design. Ling-Temco-Vought / Bill Rose

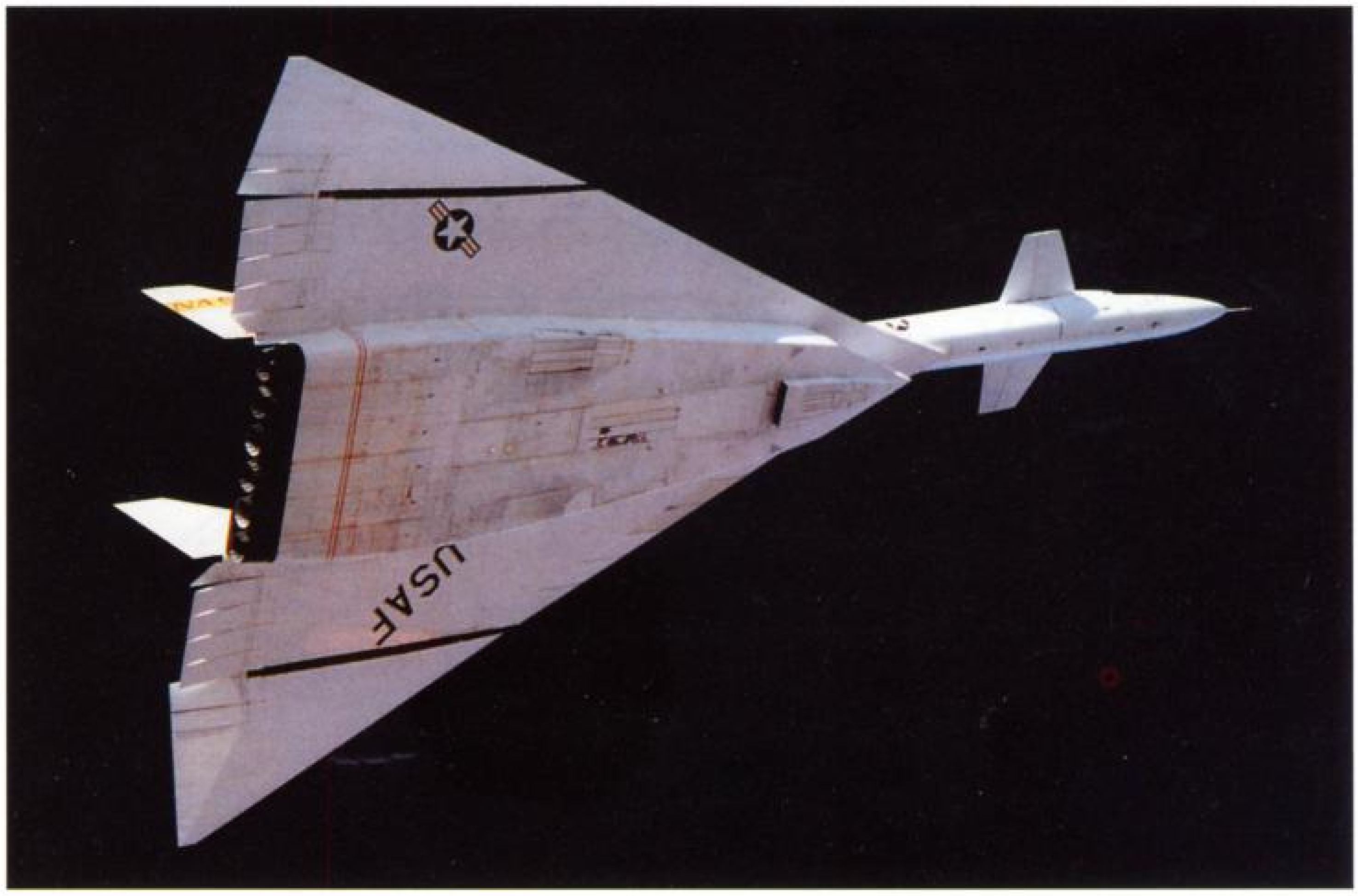
Vought ADAM-11 V-482 aircraft in flight. Tony Buttler/Bill Rose



Ling-Temco-Vought's application of the ADAM concept to a proposed 75-ton civil and military VTOL transport aircraft. Ling-Temco-Vought



The highly advanced North American XB-70A Mach 3 bomber. NASA



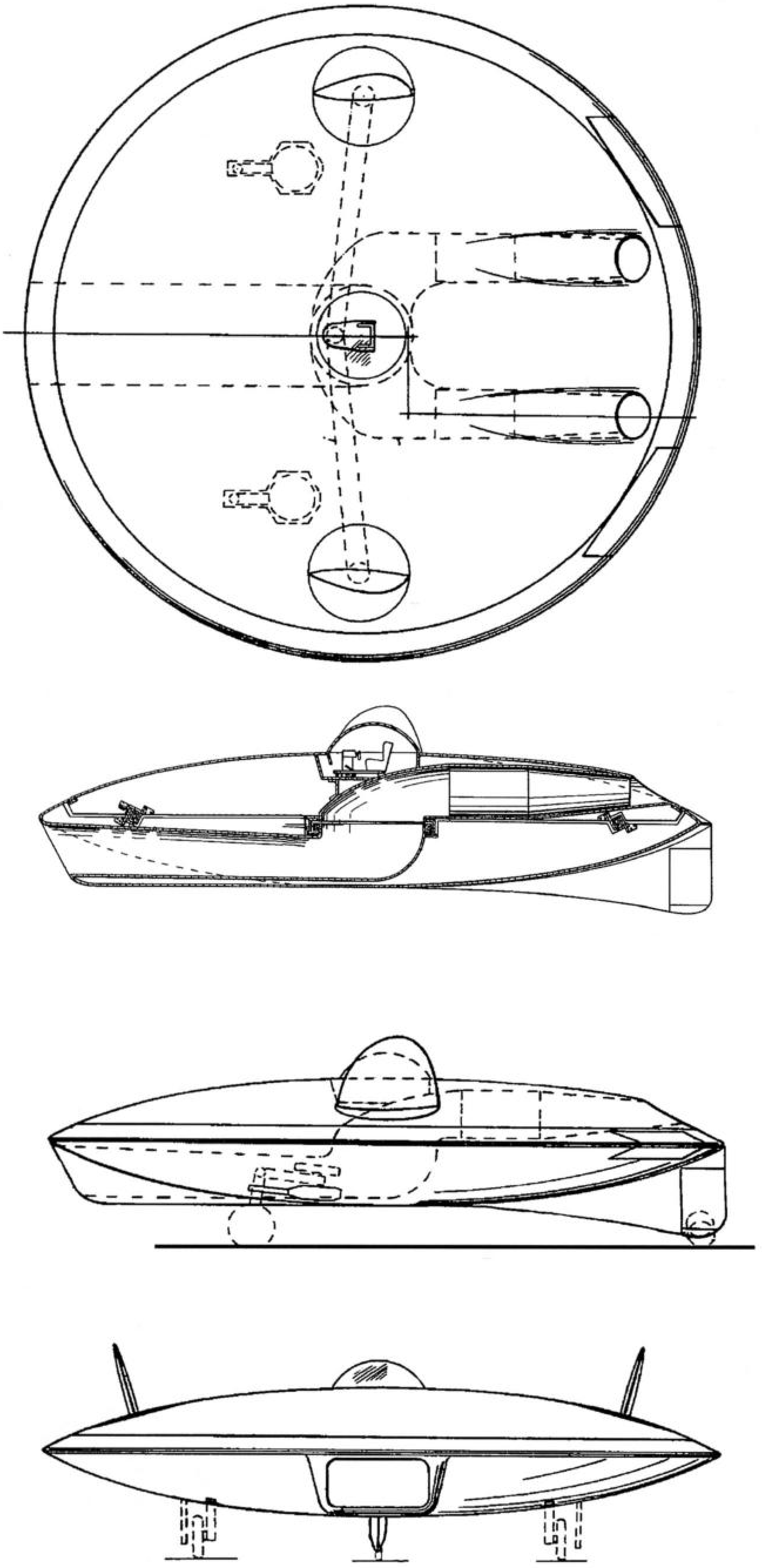
the V-482 and V-485, but they were both generally referred to as the ADAM II. These aircraft were expected to have a VTOL capability and a good overload STOL performance, with supersonic speed in level flight. The overall shape of the aircraft would be configured to take full advantage of the fan flow. Booms would be fitted to each wingtip and each was equipped with a tailfin, providing a V-shaped configuration. The large flaps behind the wings would primarily act as panels for flow deflection, taking on the role of ailerons in level flight. Designers expected the aircraft to remain flyable with one engine shut down, so that a sudden engine failure would not lead to a complete loss of control. V-482 was configured as a single-seat interceptor, while V-485 would be a somewhat larger two-seat attack aircraft with an anticipated weight of approximately 30,000 lb (13,608kg). Weapons were not discussed in available documents, but artwork suggests a wide range of external stores from air-to-air missiles to free-fall bombs.

As Ling-Temco-Vought's Design team continued to explore the ADAM concept they produced proposals for a 75-ton civil and military VTOL transport aircraft using the same propulsive principle. Nevertheless, despite strong promotion by Vought, the Pentagon took no further interest in ADAM and the project was formally terminated in 1965.

Pye Wacket

At some point in the early 1950s it was recognised that a disc-shaped aircraft could perform aerobatic manoeuvres that were not possible with conventional fixed wing design. One particularly interesting example of this thinking came from the San Diego-based aerospace specialist John C Fischer Jnr, who designed a high-performance one-man flying disc in 1954 that was powered by two jet engines and used rotating upper and lower shells to allow sharp flat turns without banking.

Although Fischer's concept came to nothing, proposals for a radically different hypersonic missile with extreme manoeuvring capabilities were produced by the USAF's Air Proving Ground Center at Eglin AFB and the Arnold Engineering Development Center (AEDC) during the late 1950s. This highly



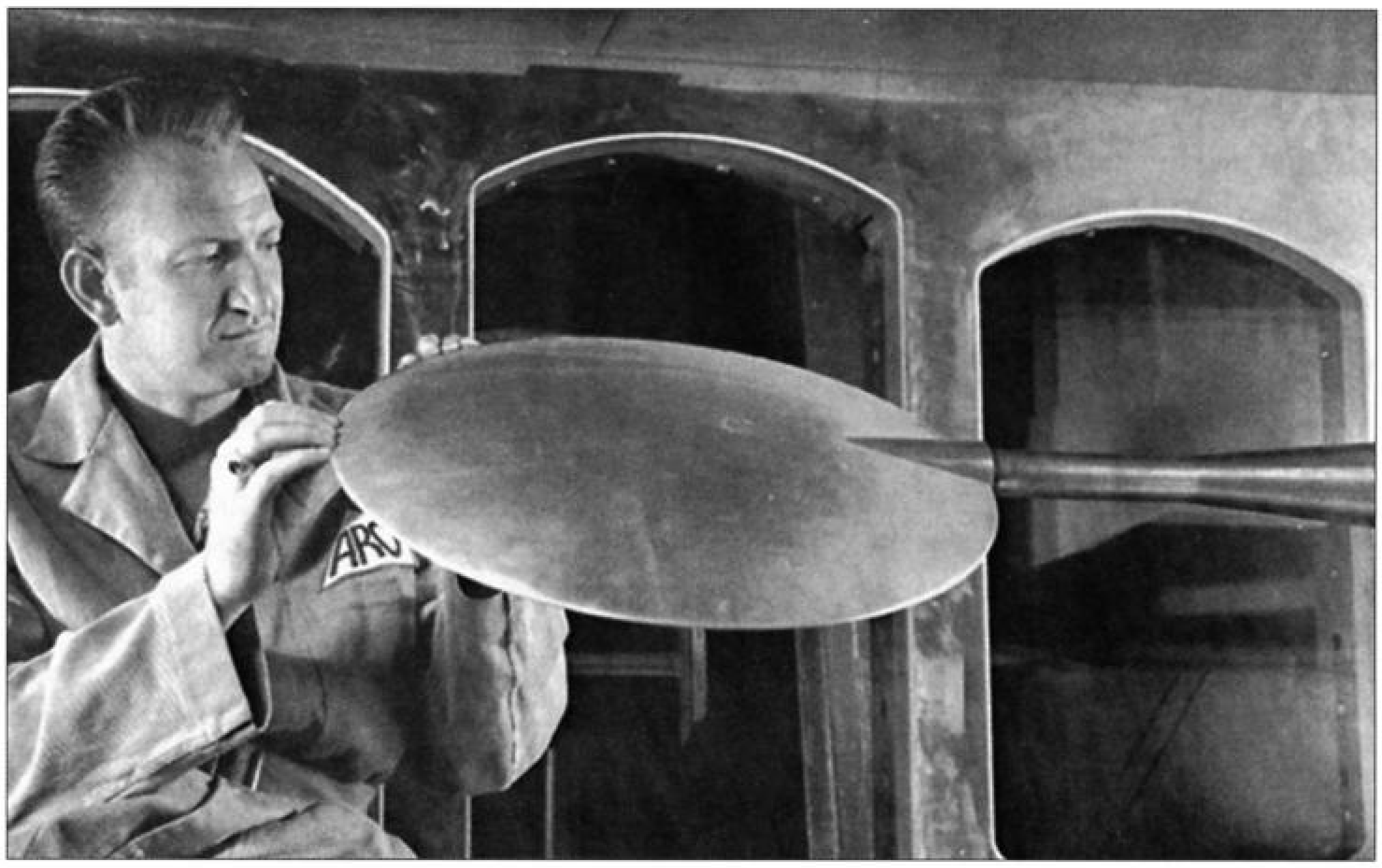
Flying saucer fighter design by John C Fischer Jnr in 1954. This unusual concept was configured for high manoeuvrability. US Patent Office

advanced air-to-air missile was intended to form a key part of the forthcoming North American B-70 Valkyrie bomber's defensive system. Initially known as the Defensive Anti-Missile System (DAMS), it was also assigned the codename Pye Wacket. The unusual name Pyewacket (originally one word) was borrowed from the mystical cat which appeared in the 1958 movie *Bell, Book & Candle*, which starred James Stewart and Kim Novak.

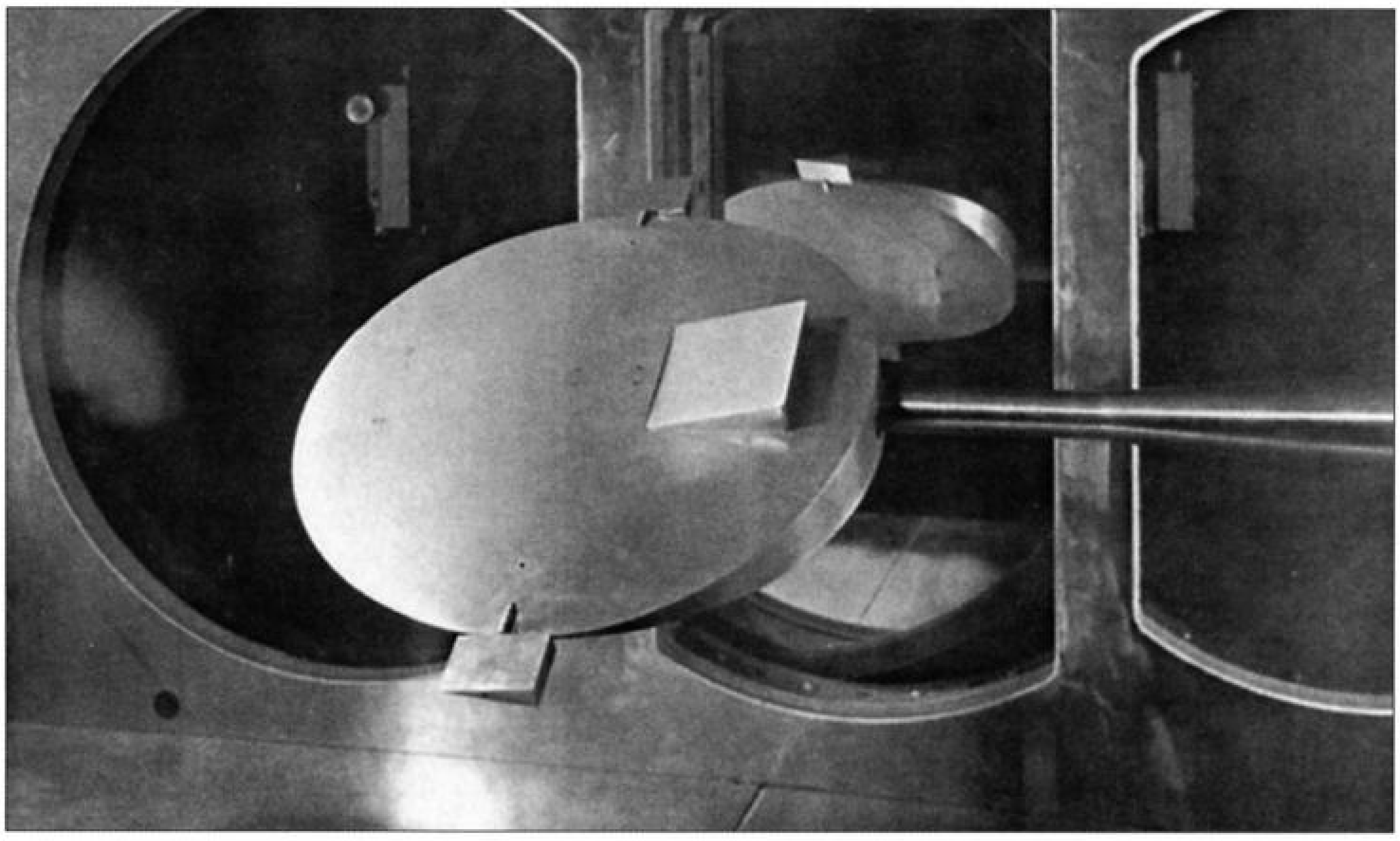
Although the B-70 would operate at a speed and altitude that placed it beyond the reach of most Russian air defence systems, US designers anticipated more capable Soviet interceptors (like the Mikoyan MiG-25 Foxbat) and more advanced surface- and air-launched missiles equipped with low-yield nuclear warheads. The B-70 would carry state-of-the-art electronic countermeasures and rearward-launched nuclear-tipped air-to-air missiles, but it was felt that Pye Wacket was needed to deal with all possible threats.

As the project evolved in association with North American Aviation, DAMS took the form of a small disc- or lenticular-shaped vehicle, powered by three solid-fuel Thiokol M58A2 rocket motors that were similar to those used in the early Hughes AIM-4 Falcon air-to-air missile. This was expected to provide a speed of about Mach 6.5, a range of 82 miles (133km) and a phenomenal manoeuvring ability. Missiles would be vertically stacked in the B-70's bomb bay on two separate posts, each holding five Pye Wackets. The missile would be launched from the aircraft by means of a percussion ejector and the rocket motors ignited once clear of the bomber. Pye Wacket would be able to execute turns that were way beyond the capability of any manned vehicle or guided missile and this performance allowed engagements with head-on targets closing as fast as Mach 7.

The name Pye Wacket was used throughout the project, but DAMS caused some confusion with USAF personnel and in 1958 the official designation was changed to Lenticular Defense Missile (LDM) to reflect the shape of the vehicle. In June 1959 the USAF issued Convair with a classified contract to continue development of LDM and they produced three scale models for wind tunnel testing known as B1 to B3. This was mostly undertaken at the 40in (101.6cm) Tunnel A of the von Karman Gas Dynamics Facility at AEDC. It soon became clear that the disc shape provided outstanding stability at speeds up to Mach 6 and allowed



A scale Pye Wacket Model B1 undergoing wind tunnel testing at Tunnel A of the von Karman Gas Dynamics Facility in the Arnold Engineering Development Center. USAF



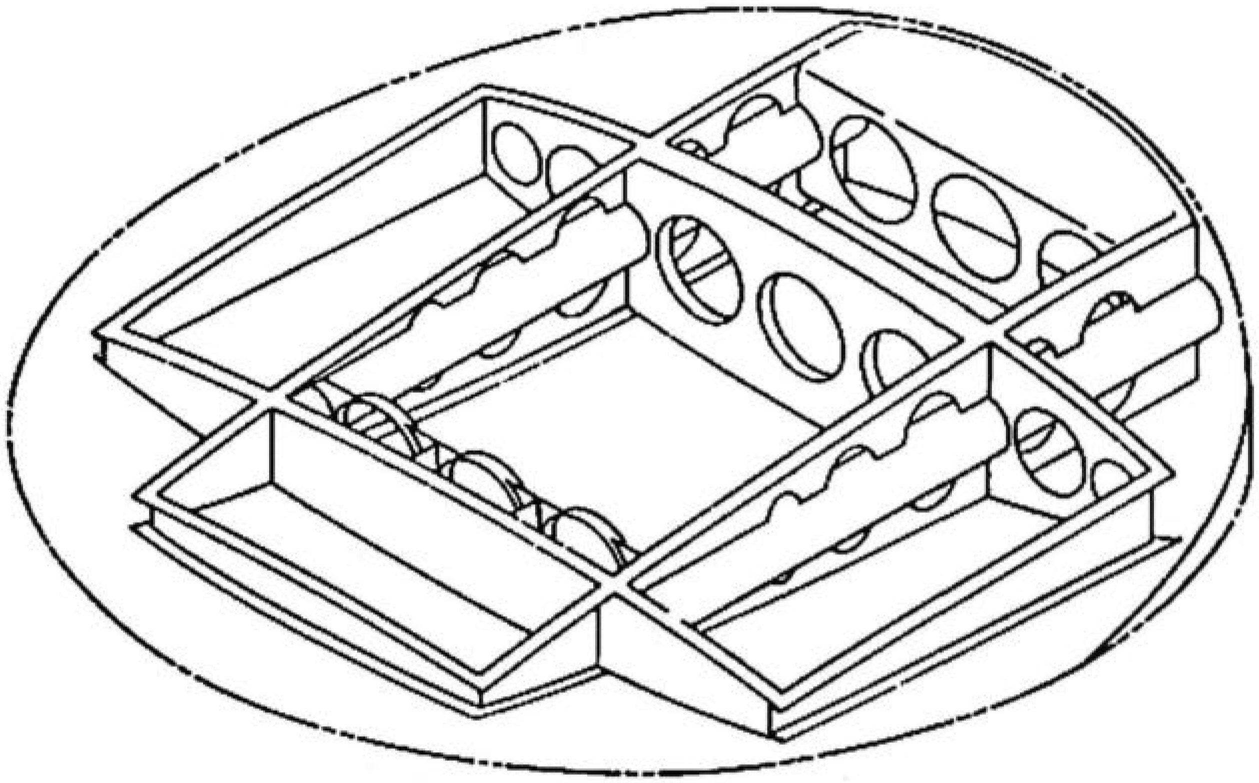
Pye Wacket Model B3 undergoing wind tunnel testing. This was the only wind tunnel model that was tested with lateral control surfaces. USAF

unprecedented agility. Various control devices were also tested which included flaps, vanes, and other moving surfaces.

By early 1960 the wedge-shaped circular B3 vehicle had been selected along with a reaction control system comprising four thrusters for pitch and a further two for yaw. The initial design of this missile had a diameter of 60in (1.52m), a maximum thickness of 12in (30.5cm) and a gross weight of 425 lb (193kg). The USAF planned to make test launches of Pye Wacket from a rocket sled and rumours persist that several air launches of full-sized vehicles were conducted at the White Sands Missile Range during 1960, but no details have ever been released.

The warhead intended for Pye Wacket remains unclear but there are indications that several options were considered, which included a conventional explosive design and an exotic low-yield nuclear type. Just prior to launch from the B-70, targeting data would be downloaded to the missile's computer from the aircraft's fire control system. The missile would be able to approach an inbound target coming from any direction and terminal guidance took the form of an infra-red seeker. On the other hand, it appears that expectations for this system may have been somewhat greater than what was technically feasible at that time.

Pye Wacket continued to evolve and the diameter was increased to 70in (1.78m) while the disc became shallower with a maximum thickness of 9in (22.9cm); it gained a little weight at 510 lb (231kg). It was also decided that propulsion could be adequately handled by two rocket motors with 10,200 lb (45,5kN) thrust, which would provide the same level of performance. Pye Wacket was officially cancelled in 1961, when it was decided that the B-70 would not require any form of missile defence system. But work may have continued at Eglin and Wright-Patterson AFB under Project 5155 (Vehicle Defence Techniques), which examined defensive measures for boost phase, near-space and extraterrestrial vehicles using a missile with a radiation warhead.



Pye Wacket missile airframe structure. USAF

Chapter Five

Russian Flying Discs Myth and Reality

As UFO sightings began to gather momentum during the early post-war years, there was an increasing suspicion within the Western intelligence community that some of the more reliable reports might be describing new types of military aircraft built in the Soviet Union. There were very real concerns that the Russians had captured advanced technology from the Germans, allowing them to produce high-performance flying discs that were as least as good as the anticipated Avro Canada design and perhaps superior. The CIA had a relatively limited ability to gather information from behind the Iron Curtain and in some quarters speculation was rife.

Like the West, Russia had taken full advantage of German scientific developments and an East-West arms race was under way which would last for decades and cost trillions of dollars. The first claims that new Soviet high-performance aircraft or missiles were undergoing tests appeared in Scandinavian newspapers during 1946. They reported unexplained bright fireballs dubbed 'Ghost Rockets', which were being regularly observed over Sweden, Norway, Finland and Denmark. The Swedish government began an official investigation, which involved British Intelligence, but they eventually concluded that the sightings were of natural phenomena.

A bright fireball with an approximate magnitude of -8 passes across the Nevada night sky. These remain usual and interesting events for all astronomers and the number of 'green fireballs' sighted above New Mexico in the late 1940s has never been properly explained. Bill Rose

These events were followed in 1948 by unusual sightings of 'green fireballs' in the night skies above New Mexico. The New Mexico reports were investigated for the USAF by Dr Lincoln La Paz, who was the Director of the University of New Mexico's Institute of Meteoritics. He concluded that the green fireballs were artificial objects because of their low velocities and flat trajectories. This study was immediately classified secret by the USAF, but increasing public and media interest made it hard to play the issue down.

The USAF feared that the fireballs might be the visible signs of a new Soviet weapon and they commissioned further studies that were undertaken by Dr Joseph Kaplan from the University of California at Los Angeles (UCLA). Kaplan's findings were reported on 3rd November 1949 and he concluded that, despite being unusual, the meteors were of natural origin and had been observed because of good 'seeing' conditions in New Mexico. He also noted the public's heightened awareness of unusual activity in the night sky due to UFO reports in the press. However, just over three years later Dr La Paz contradicted his colleague's report when he told the media that many pieces of evidence indicated that green fireballs seen around the world were a new type of missile, possibly of Soviet origin.

On 28th June 1952 the West German newspaper *Saarbrücker Zeitung* claimed that a crashed Soviet flying saucer had been discovered on the remote arctic island of Spitzbergen (Svalbard). Then the report appeared in *Berliner Volksblatt* on 9th July 1952 and was carried by *Der Flieger* during August 1952, with wider distribution being undertaken by the AFP news agency. The story was completely bogus but it reawakened concerns within the USAF and appears to have prompted a CIA investigation. The belief that the Russians possessed secret flying saucer technology persisted and this appears to have a major factor behind the US decision to fund further development of the Avro Canada flying saucer project.

Another event that took place in 1955 would reaffirm the USAF and CIA opinion that some flying saucers were of Soviet origin and the details remain intriguing and unexplained to the present day.

The Russell Affair

On 4th October 1955 a very unusual event took place in the Soviet Trans-Caucasus region, which was observed by members of a high-level American delegation who were travelling on a train. They included Republican Senator Richard Brevard Russell (1897-1971), who headed the Senate Armed Forces Committee. To quote the *New Georgia Encyclopaedia*: 'During the twentieth century Russell, along with Carl Vinson in the US House of Representatives, was undeniably among the nation's foremost experts on military and defense policy'.

Accompanying the senator were his military aide Lieutenant Colonel E Hathaway and interpreter Ruben Efron, who both served on the Senate Armed Forces Committee, and an unidentified fourth person whose name remains blacked out on official documents. They were travelling between Atjaty and Adzhijabul and apparently spent much of their time idly observing the passing countryside.

United States Senator Richard Brevard Russell, who headed the Senate Armed Forces Committee. US Congress

It was a few minutes after seven o'clock and twilight had arrived when they suddenly noticed a circular disc-shaped aircraft rising vertically into the sky from an obscured area about one mile (1.6km) away from their position. Almost exactly one minute later, it was joined by a second craft of identical appearance. Both discs were described as metallic in colour, with two bright lights on the top and they were accompanied by noticeable exhaust emissions. The unidentified aircraft then began to move towards the train and the Americans realised that two searchlights on the ground were illuminating them. Within a matter of minutes the discs had started to pick up speed and passed over the train at an altitude of about 6,000ft (1,829m), heading north. According to Lieutenant Colonel Hathaway, the railroad officials then chose to enter the compartment and insisted that all the window blinds should be lowered, which prevented any further observations.

Several days later the incident was reported to Lieutenant Colonel Thomas Ryan, who was the US Air Attaché at the US Embassy in Prague, and he immediately forwarded a Top Secret summary of events to Washington. On 19th October 1955 the CIA's Chief of Scientific Intelligence, W E Lexow, filed a secret memorandum that directly compared this type of disc-shaped aircraft to Project Y, then under development in Canada. All documents relating to this event would remain classified secret until 1985.

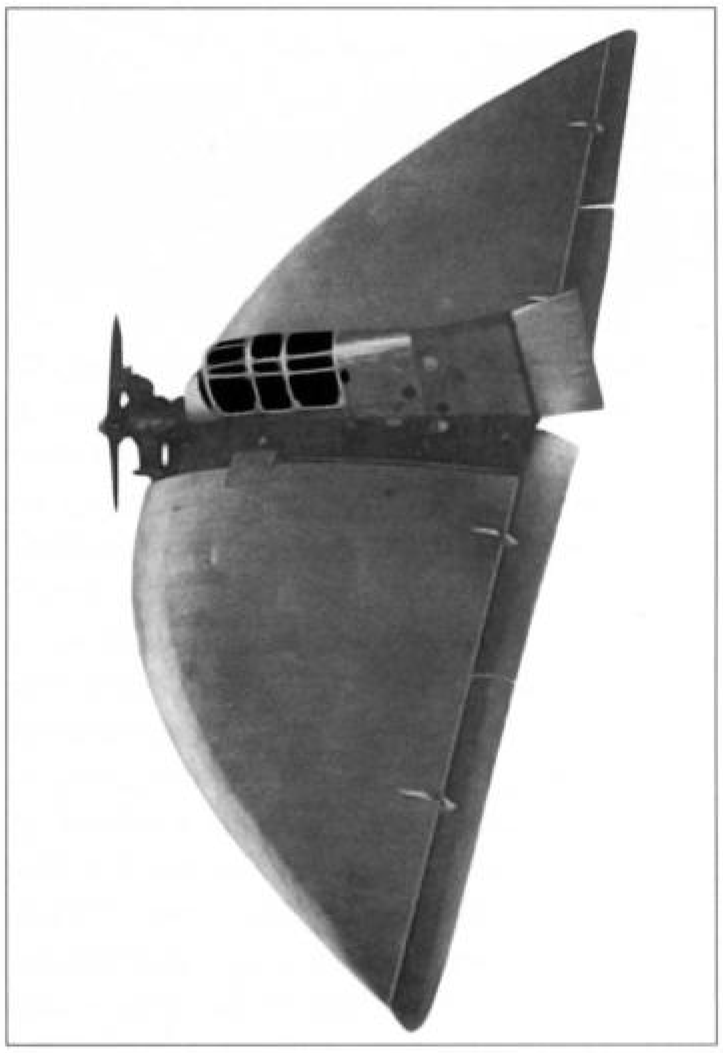
Even today a high-level delegation of American officials travelling on a Russian train would receive special attention from the Russian security services, but during the Cold War it seems likely that every step of their journey would have been carefully controlled and closely monitored by the KGB. It is hard to believe that these flying discs were accidentally observed from the train and it is tempting to think that the whole event was stage-managed for the benefit of the US Armed Forces Committee, with the full authority of Chairman Nikita Khruschev. The exact thinking behind such an obvious piece of psychological warfare remains unclear, but it definitely sent some kind of a message back to Washington. Although the Russians have never admitted to building and testing a flying saucer that resembled Silver Bug, it remains possible that such a project existed and reached the prototype testing stage.

It is also conceivable that the Soviets engaged in a lengthy programme of deception, using the West's obsession with UFO phenomena as a cover for small-scale special operations. At the present time there is insufficient evidence to make any kind of case for these theories, but there is a history of Russian interest in circular and parabola-shaped aircraft, which suggests there may be past programmes that remain classified.

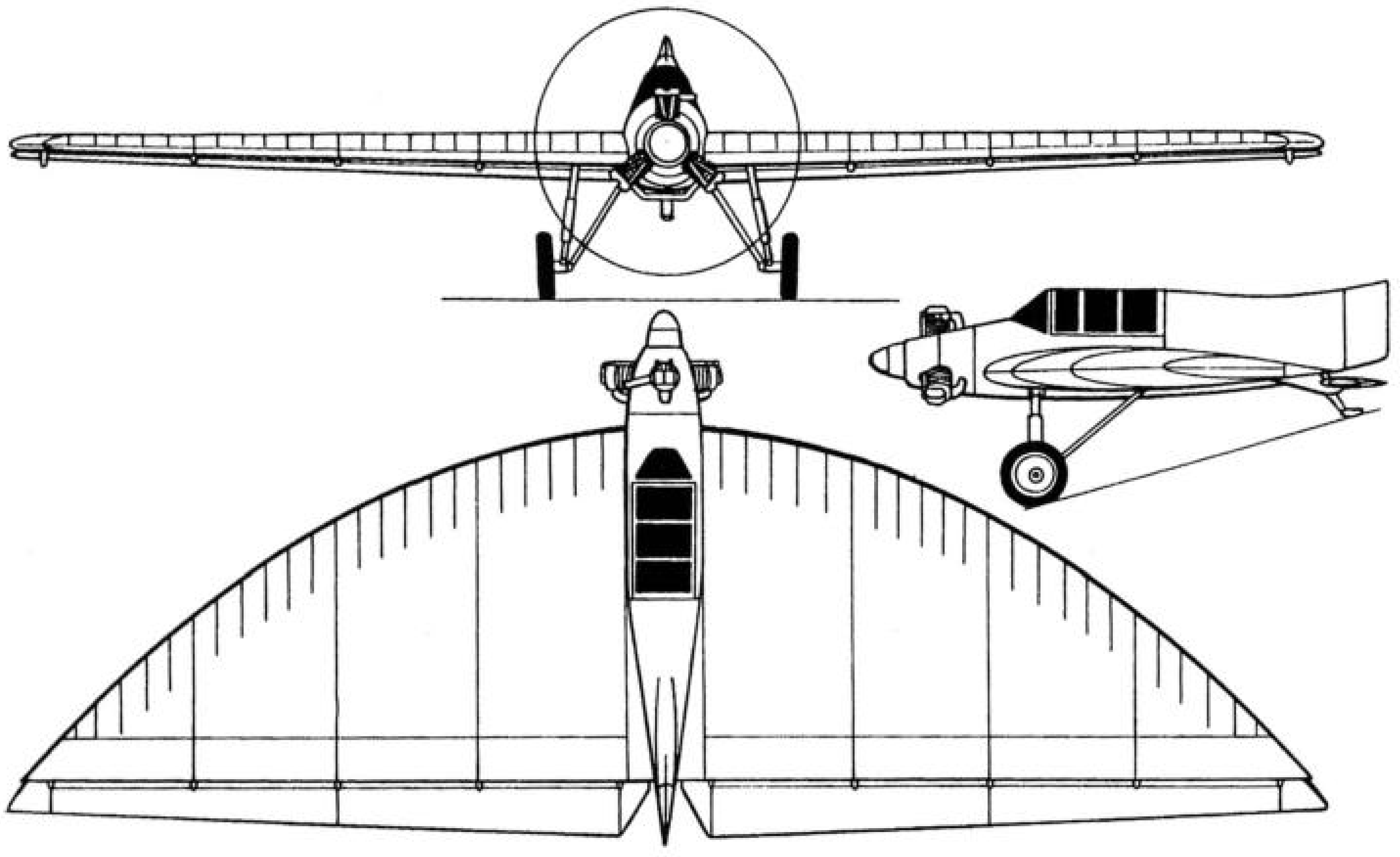
Chyeranovskii Aircraft

In 1922, Boris Ivanovich Chyeranovskii (1896-1960) entered the Zhukovskii Academy and designed the first of a series of parabola-shaped tailless flying wings. Despite some scepticism from his peers, Chyeranovskii flew a model glider of this design in the Crimea and it led to a small propeller-driven design called BICh-3, which was completed and flown in 1926. The aircraft had a wingspan of 31ft (9.45m), a length of 11ft 6in (3.5m) and a wing area of 215ft² (20.0m²). Propulsion was provided by a small 18hp (13.4kW) Blackburn Tomtit internal combustion engine and the aircraft's gross weight was about 500lb (226kg) allowing a maximum speed of approximately 85mph (136km/h).

Several parabola-shaped designs followed and, as the aerodynamics steadily improved, increasingly more powerful engines were employed. By 1929, Chyeranovskii had completed the BICh-7. This aircraft flew rather badly and was extensively rebuilt as the similar but more refined BICh-7A, which was ready for its first flight in 1932.



Chyeranovskii BICh-7A parabola-shaped aircraft. via Bill Rose



3-view drawing of the Chyeranovskii BICh-7A.

BICh-7A was essentially a scaled-up two-seat version of BICh-3 with a 100hp (74.5kW) Bristol Lucifer engine and a wingspan of 41ft (12.5m). The fixed undercarriage consisted of two forward wheels and a tailskid. BICh-7A had a gross weight of about 507lb (203kg) and an estimated maximum speed of about 100mph (160km/h). Little is known about following Chyeranovskii models that may have been designated BICh-8 to 13; they were probably unsuccessful or unbuilt designs.

The next significant Chyeranovskii aircraft was the twin-engined BICh-14, which was powered by two 100hp (74.5kW) M-11 engines. It had a wingspan of 53ft (16.1m) a length of 19ft 9in (6m) and a gross weight of 4,189lb (1,900kg). Maximum speed for BICh-14 was about 137mph (220km/h) and it flew until early 1937, when testing was cancelled. Chyeranovskii's team produced various other small tailless propeller driven designs and these culminated in the BICh-21, an advanced monoplane intended for use in the Osoaviakhim All-Union Air Race of 1941. The aircraft was completed and flown but the project soon came to an end when the war with Nazi Germany began.

In the immediate post-war years, Chyeranovskii ran an informal OKB, developing very sophisticated tailless flying wing supersonic combat aircraft with unusual configurations. How much German research influenced his design work is unclear, but the BICh-26 that emerged in 1948 was his team's most advanced concept. This single-seat fighter proposal had a semi-triangular appearance with a variable-sweep wing. Powered by one gas turbine, the aircraft had an anticipated maximum speed of Mach 1.7 and a ceiling of 72,000ft (22,000m), but the performance of available engines and those under development suggests that these figures were somewhat optimistic. Chyeranovskii finally retired due to poor health and died on 17th December 1960.

Sukhanov Discplanes

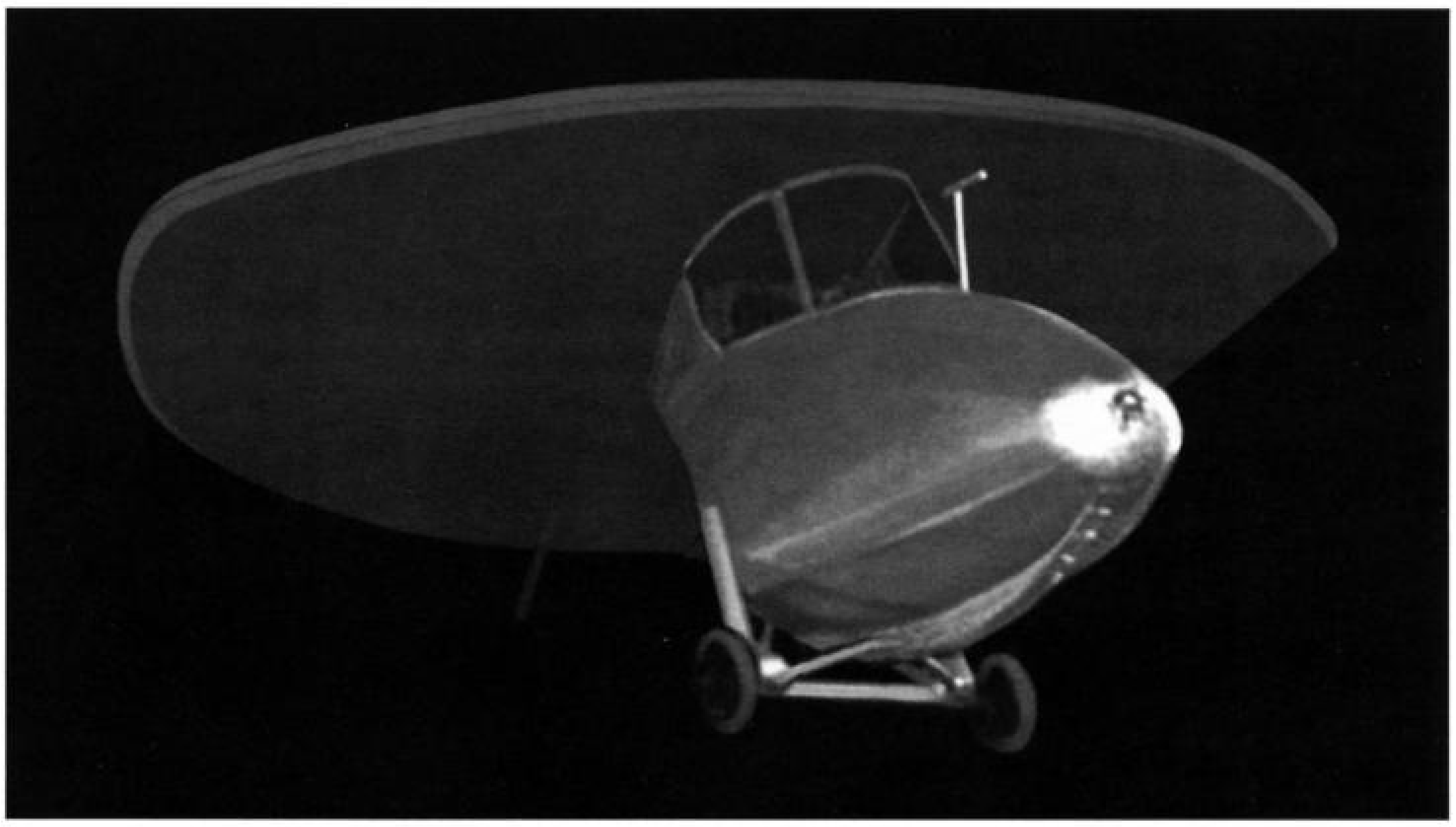
A small design team (but not thought to have an OKB designation) appears to have been responsible for most of the circular-winged aircraft that were designed in the Soviet Union from the 1950s onwards. Headed by M Sukhanov (first name unknown), this design group created a series of compact gliders, powered aircraft, ground-effect vehicles and numerous exotic concepts.

According to Colonel-General B Korolkov, commander of the Russian Air Force Academy, and V Kazashvili, the curator of the Russian Federation Air Force Museum at Monino, the first Sukhanov Discoplan 1 was built at Novosibirsk. This is believed to be the same compact single-seat glider that flew at Tushino in 1958. It comprised a one-piece circular wing with a diameter of 16ft (5m) and it was fitted with an upper mounted tailfin. A pod-shaped cockpit was located below the wing and the undercarriage comprised two wheels on struts plus skids attached to the wing's trailing edge.

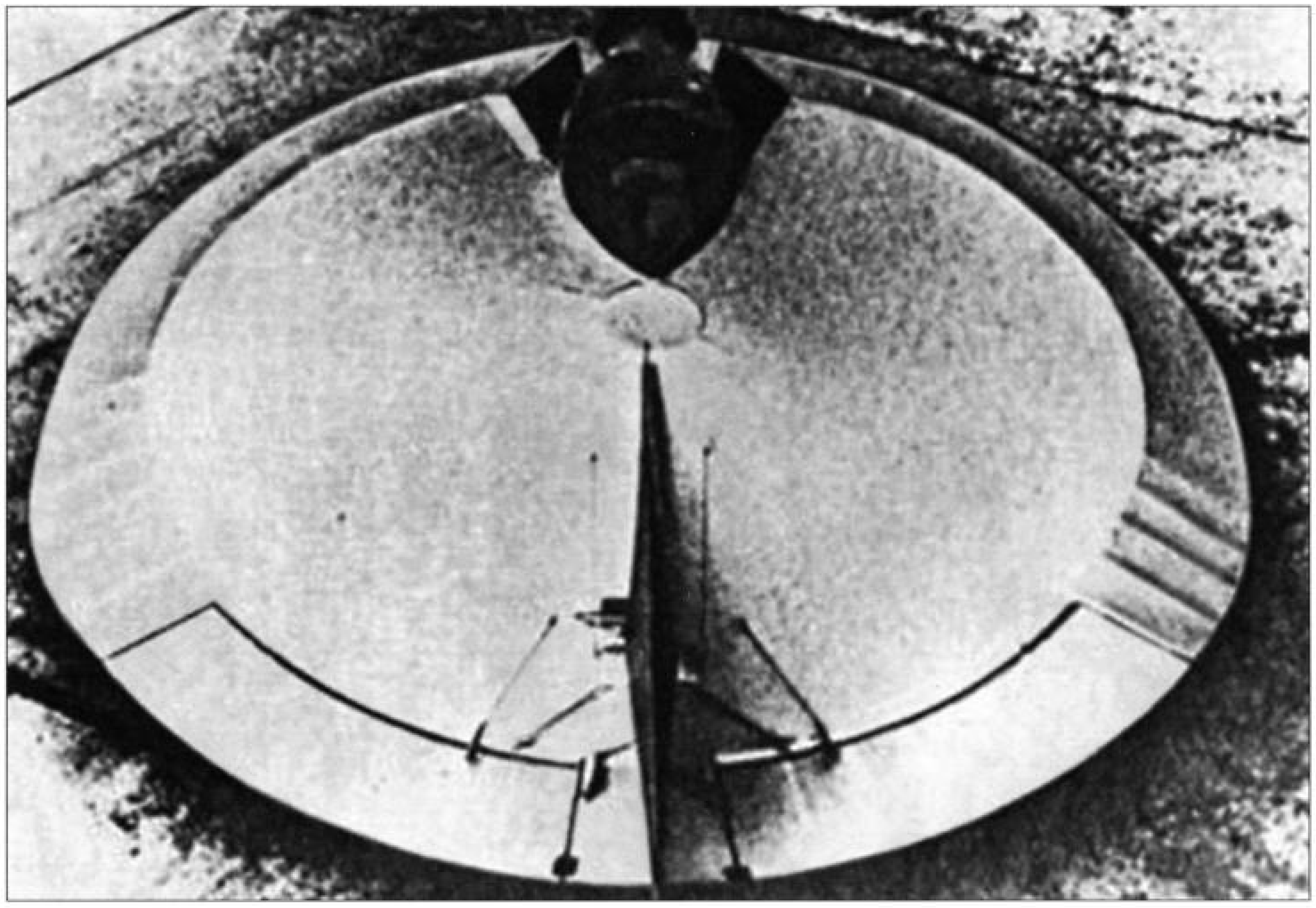
Sukhanov's Discoplan II was completed in 1960 at the Lavochkin plant and it was another small glider that was designed to test new wing ideas. A third Sukhanov glider was completed during the 1959-1962 period and utilised more of a rectangular shape. The aircraft was fitted with a single tail fin and had a forward-positioned bubble cockpit.

This small aircraft may have been used to test the viability of a larger manned re-entry vehicle for Russia's space programme and there were apparently plans to follow this with a turbojet-powered version.

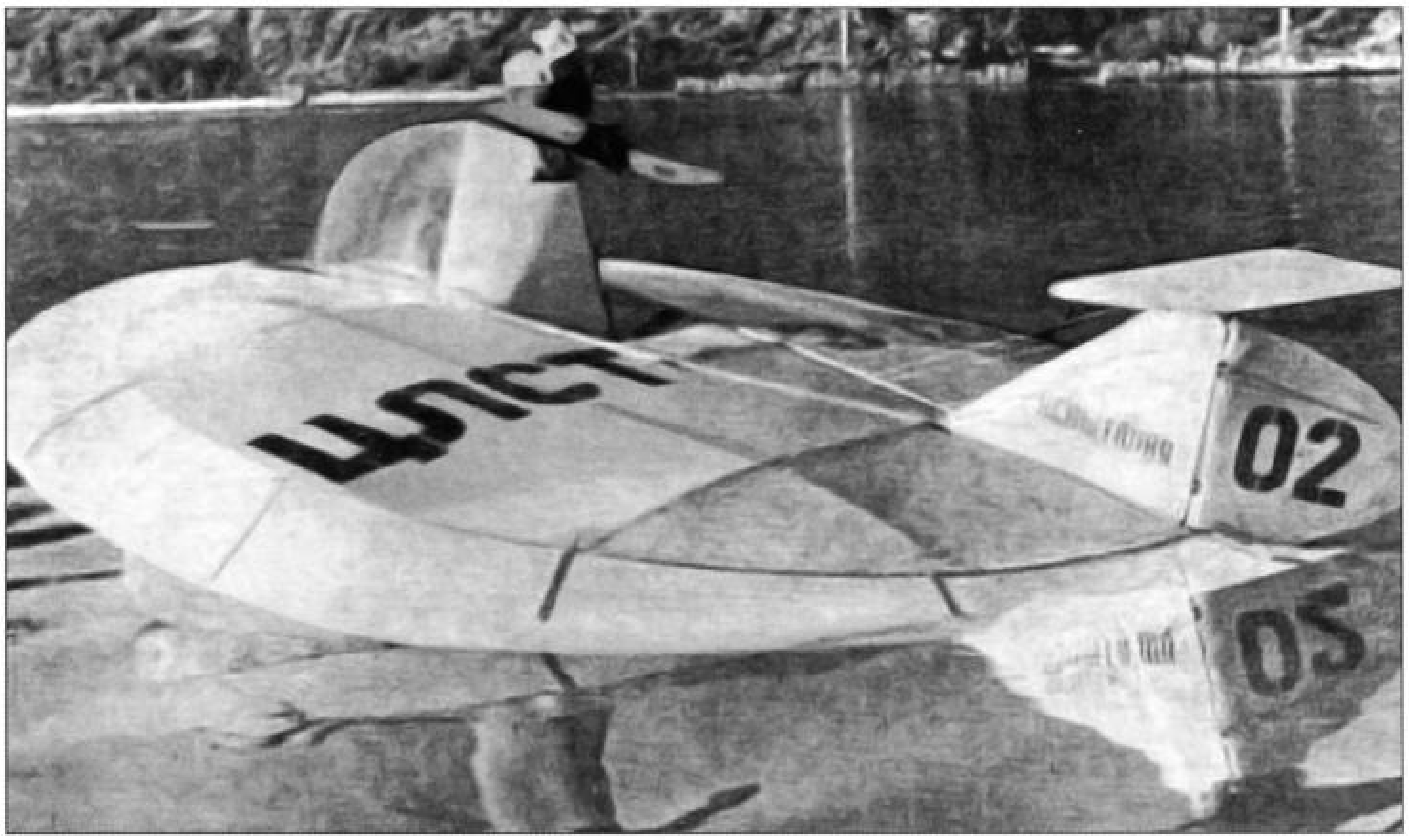
The Sukhanov team were also involved in the design of an Avrocar-type vehicle, which appears in one poor quality photograph. In 1957, *Sovietskaya Rossiya* magazine briefly discussed a counterpart to the Avrocar craft, crediting the design to Professor S Zonshtein. It was described as a 'circular object with four ducted fans'. The vehicle seen in a picture (which may be this machine) has a bubble cockpit and is fitted with a single tailfin. Whether or not it performed any better than the Avrocar is unknown. At about the same time the Russians



Russian Sukhanov Discoplane. Bill Rose Collection



Sukhanov disc-shaped vehicle, which may have been the equivalent of Avrocar. Thought to have been built during the same period in time. via Bill Rose



Circular-shaped Russian hydroplane, associated with designer A J Tento, but possibly created by Sukhanov. via Bill Rose

also built a VTOL test vehicle, which was similar in concept to the Rolls-Royce Thrust Measuring Rig research vehicle, otherwise known as the 'Flying Bedstead'. This Soviet equivalent was called the Turbolyot and was designed by Aram Nazarovich Rafaelyants. In October 1957 it was demonstrated publicly in free flight.

How much progress was made with VTOL/STOL disc-shaped aircraft or early hovercraft has never been disclosed, but one other Sukhanov circular, propeller-driven craft was a small seaplane. Nothing is known about this design or its history. It is probable that the Sukhanov team were involved with the design of high-performance circular-winged aircraft that reflected work being undertaken in the West, but details have never been released. Whether or not Sukhanov were responsible for designing the flying discs that in 1955 were reportedly seen from the train travelling through the Trans-Caucasus region by Senator Russell's delegation remains unknown.

EKIP

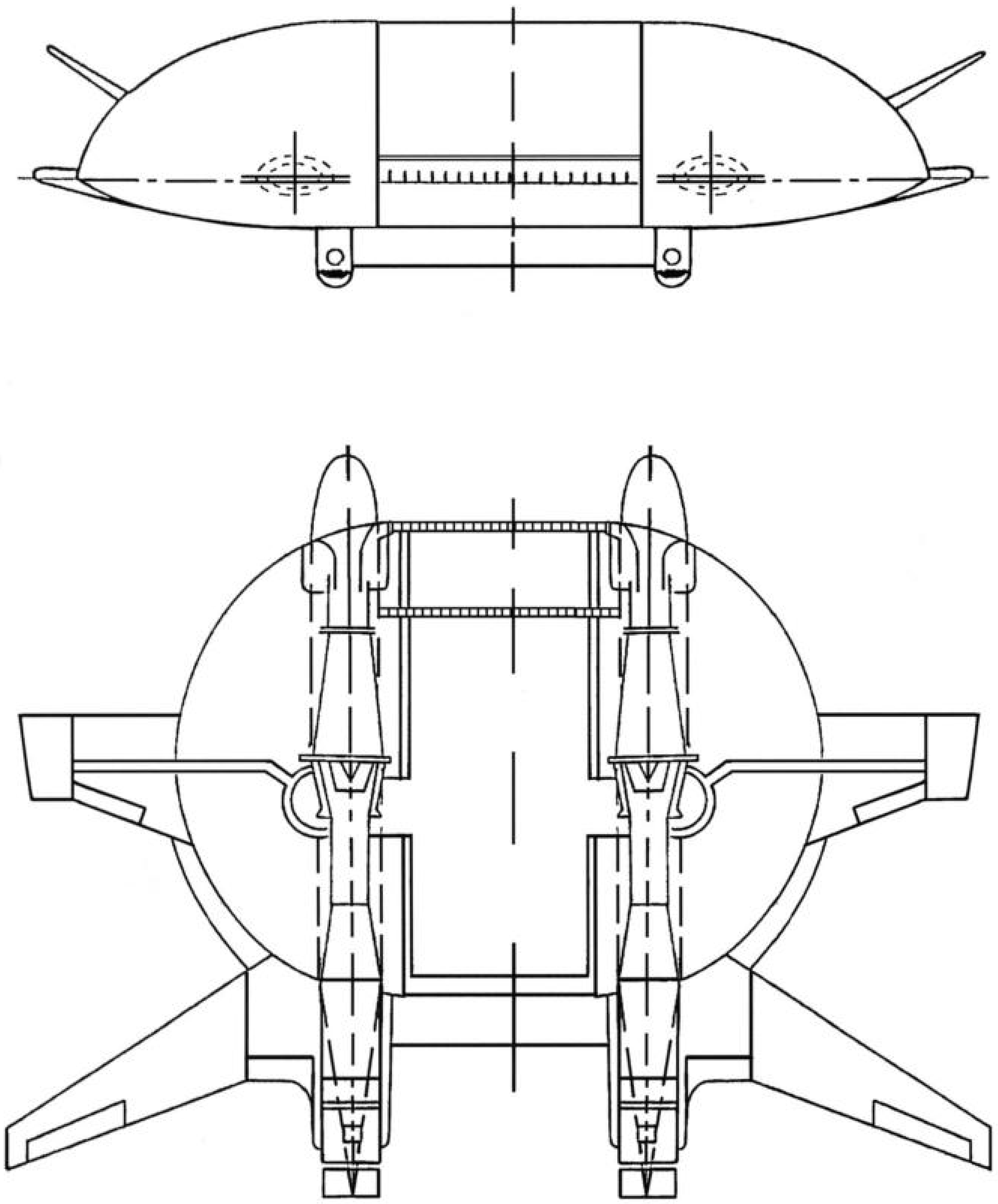
At the start of the 1990s Saratov Aviation, who are one of the largest privatised manufacturing companies in Russia (and best known in the West for building Yakovlev aircraft), started design work on an extraordinary machine that would come to be regarded by the media as Russia's UFO. Utilising a number of known but largely unproven aerodynamic principles, which included boundary layer control and vortex oscillating propulsion, this design was called EKIP for 'Ekologiya i Progres' (Ecology and Progress). It was developed by a team of engineers working under the direction of Professor Lev Nikolaevich Schukin and Alexander Sobko.

The proposed production version of EKIP would be capable of travelling at speeds of 100mph (160km/h) just above ground or water level using an air cushion and behaving like a wing-in-ground-effect vehicle. As a more conventional aircraft, EKIP was expected to reach a maximum speed of 435mph (700km/h) at normal altitudes, with an estimated ceiling of 42,000ft (12,800m). Payloads would be in excess of 99,000 lb (45,000kg) for the small manned version and 793,664 lb (360,000kg) for the larger cargo-carrying craft, which would have a range in excess of 3,278 miles (6,000km).

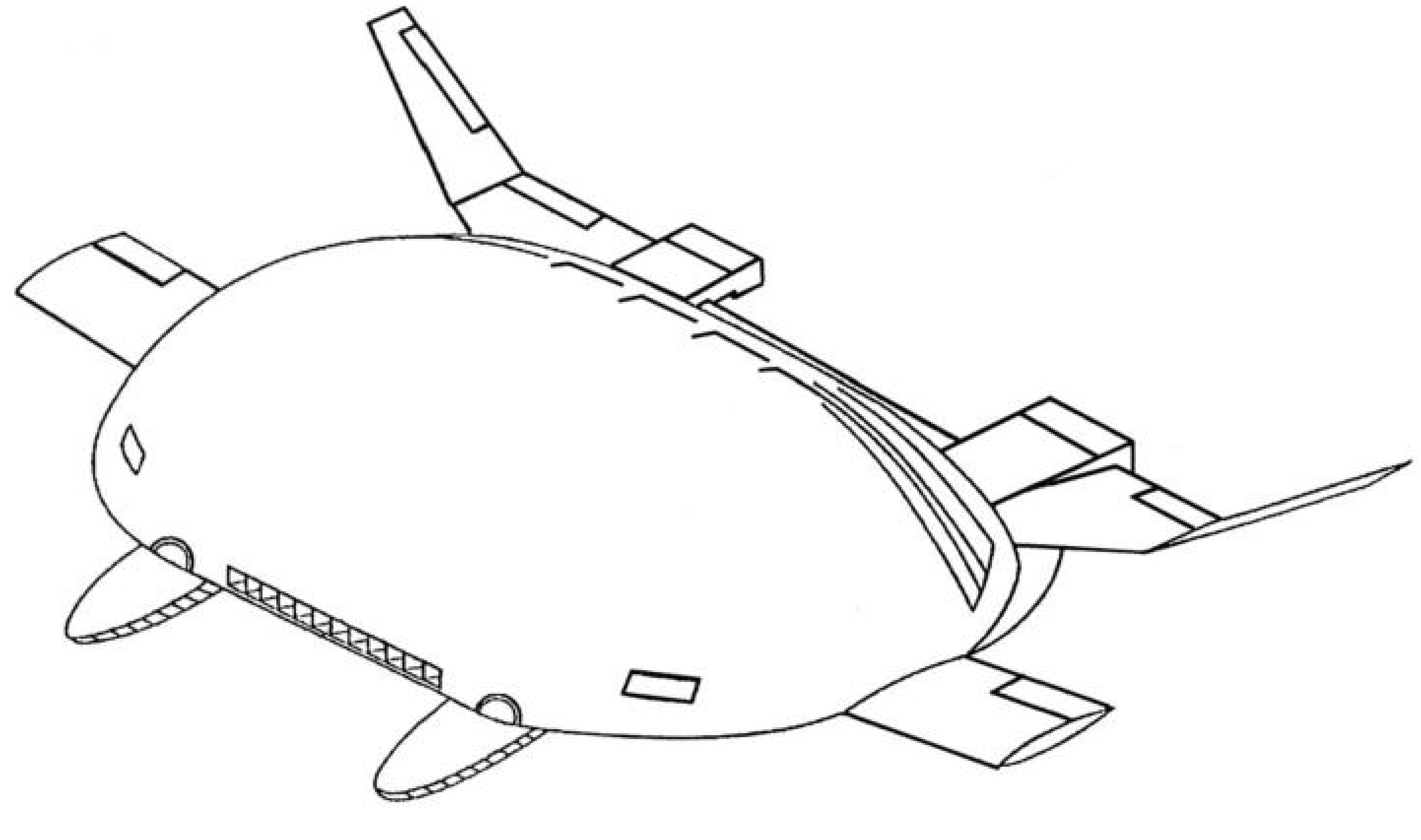
EKIP would be equipped with a cushioned landing gear system, which would allow it to operate from normal airfields, improvised areas and reasonably smooth water. But EKIP was not designed for VTOL operation and could not hover at altitude (in the sense of a helicopter or the British Harrier attack aircraft). The largest version would be able to leave the ground in less that 1,640ft (500m). With fuel economy and ease of construction high on the list of requirements, EKIP could be described as almost everything Avrocar aspired to be and a good deal more.

Stage One of the development programme established the viability of the boundary layer control system and complex airflow requirements, with research being undertaken by several specialist organisations and companies. These included TsNIIMASH (The Central Research Institute for Machine Building) and S P Korolev RSC Energia, who utilised custom-designed test stands.

Once wind tunnel testing had been completed, Saratov constructed a small proof of concept remote-controlled model, which flew during 1994. This was followed by a 26,455 lb (12,000kg) unmanned prototype, which flew in 1996. Apparently the airframe for this prototype was fabricated by S P Korolev RSC Energia and assembled by Saratov Aviation, with the possible designation L-1 being allocated. According to several reports, there were serious stability problems with each prototype and various tail fin



This drawing of a manned EKIP proposal gives some indication of how the propulsive system functions. EKIP



Drawing of advanced EKIP proposal. EKIP

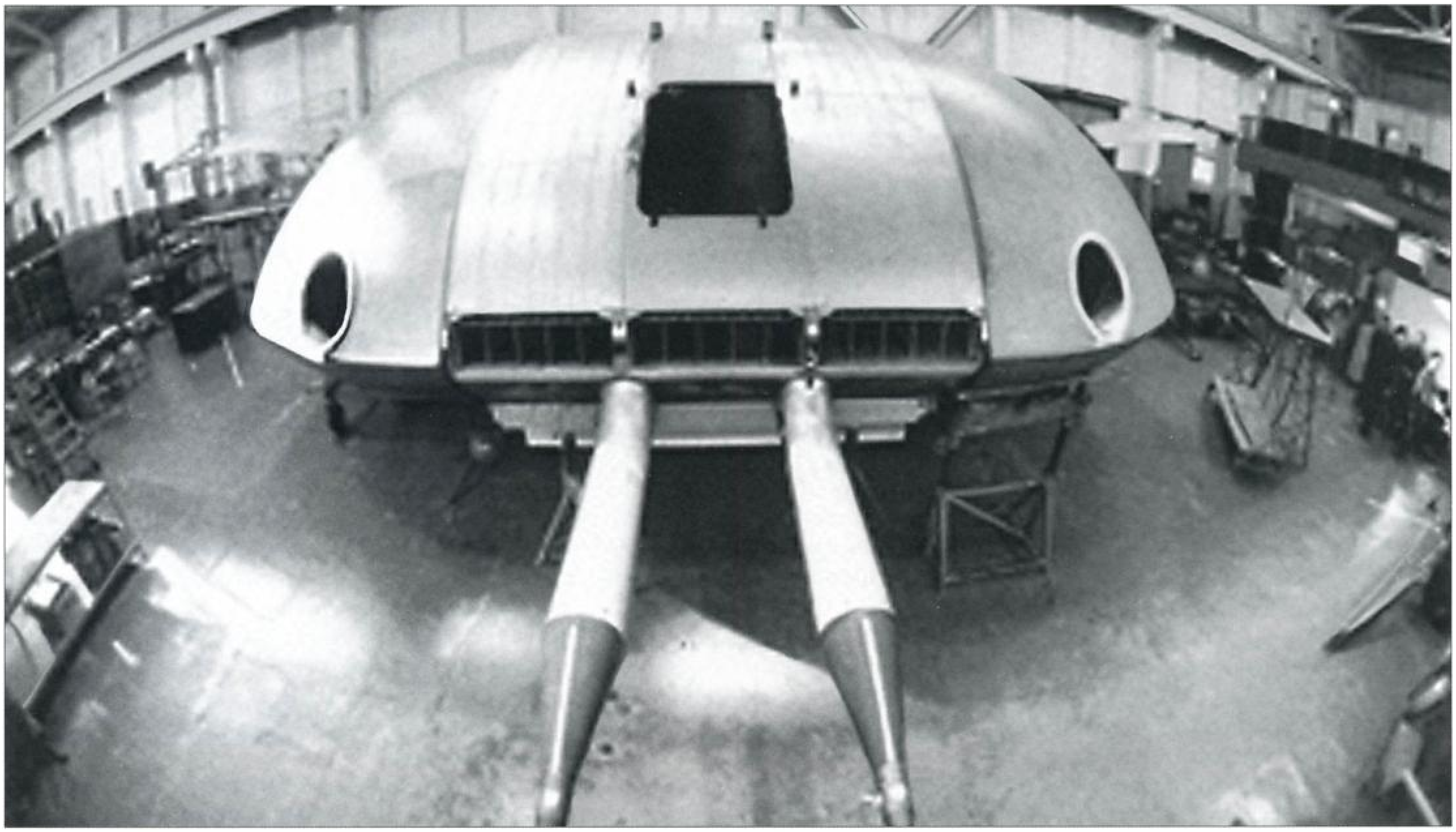
arrangements were tested to overcome this, but the ongoing research programme provided results that were generally encouraging.

It was hoped to follow the L-1 vehicle with an even larger one-man prototype built from steel and composite materials, with a fully equipped cockpit and an ejector seat. For propulsion, all larger versions of EKIP would use two turbofan engines with reheat that was applied for STOL operation. Air inlets are positioned at the front of the aircraft and letterbox exhaust ducts fitted that swivel for thrust vectoring. Two additional gas turbines would be employed for lift and there are thought to be a series of vents or louvres at the lower rear of the vehicle's underside. All four engines would be designed to run on a variety of fuels from aviation grade kerosene to liquefied gas.

EKIP could best be described as a lifting body aircraft and ground effect vehicle hybrid, but without a skirt – the small wings are for control rather than lift. The relatively high lift-drag ratio and laminar flow provided by the boundary layer control system appears to be the key feature allowing this machine to perform as an aircraft. EKIP would be able to make very steep descents at an angle of attack as great as 40°, a feature made possible by the vortex boundary layer airflow control system, which ensures a constant airflow at high angles of attack. The designers have also claimed that EKIP could make a satisfactory emergency landing in the event of total engine power loss.

Unfortunately, despite great promise, the cash-strapped Russian government was unwilling to continue funding experimental projects like EKIP and the project came to a halt in the late 1990s. EKIP then remained dormant until the Americans took an interest and NAVAIR began to explore the possibility of taking over development. During 2005 various journals reported that NAVAIR had formalised an agreement with Saratov Aviation to jointly develop EKIP as a manned and unmanned combat/transport vehicle for the US Navy and US Marines. Some reports mentioned the initial construction of a new small Unmanned Aerial Vehicle (UAV) version of EKIP weighing 500 lb (226kg), which would fly at NAS Patuxent River during 2007.

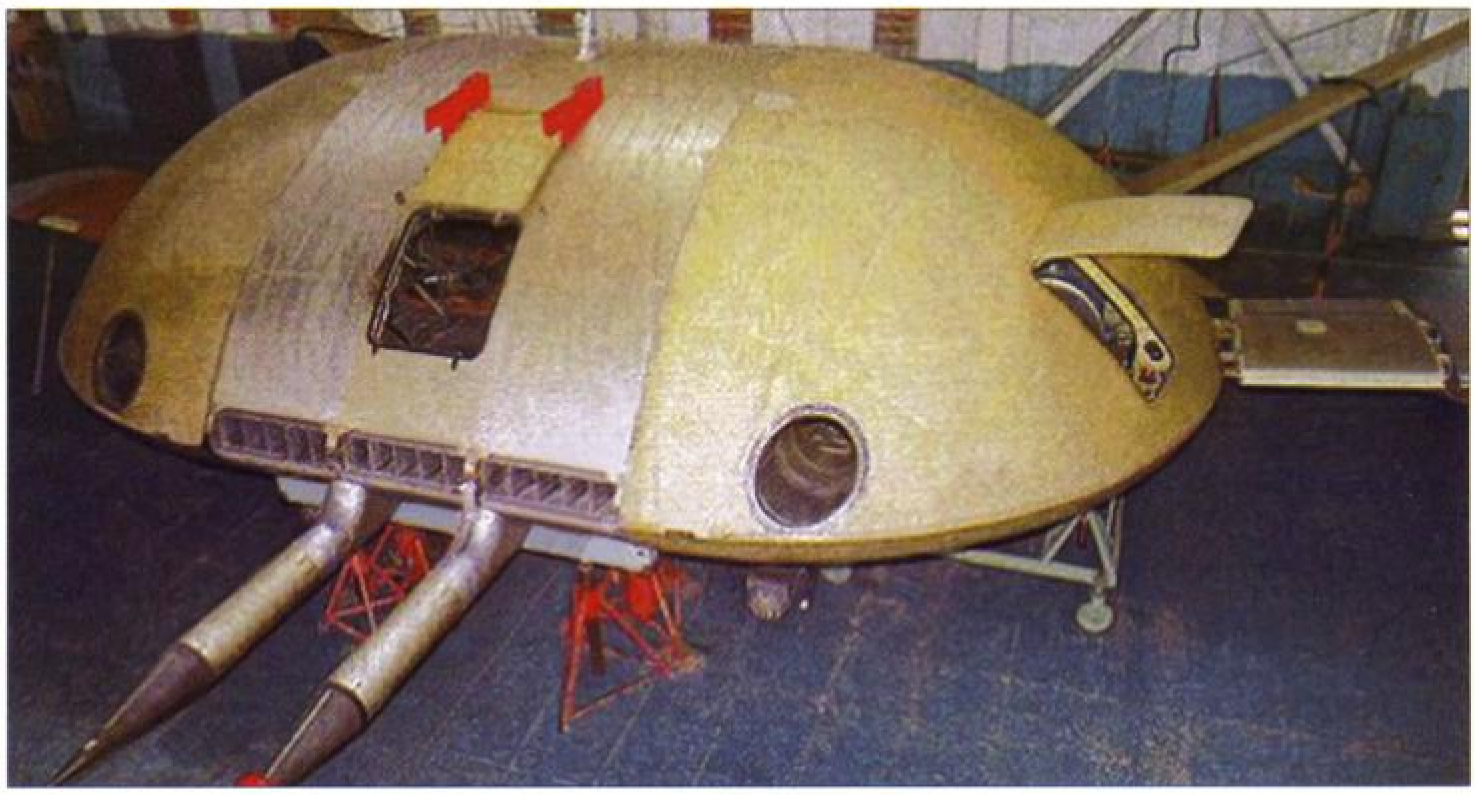
However, during July 2005, NAVAIR made it clear that the EKIP project was at an end and there were no plans to pursue further development of propulsion systems for these

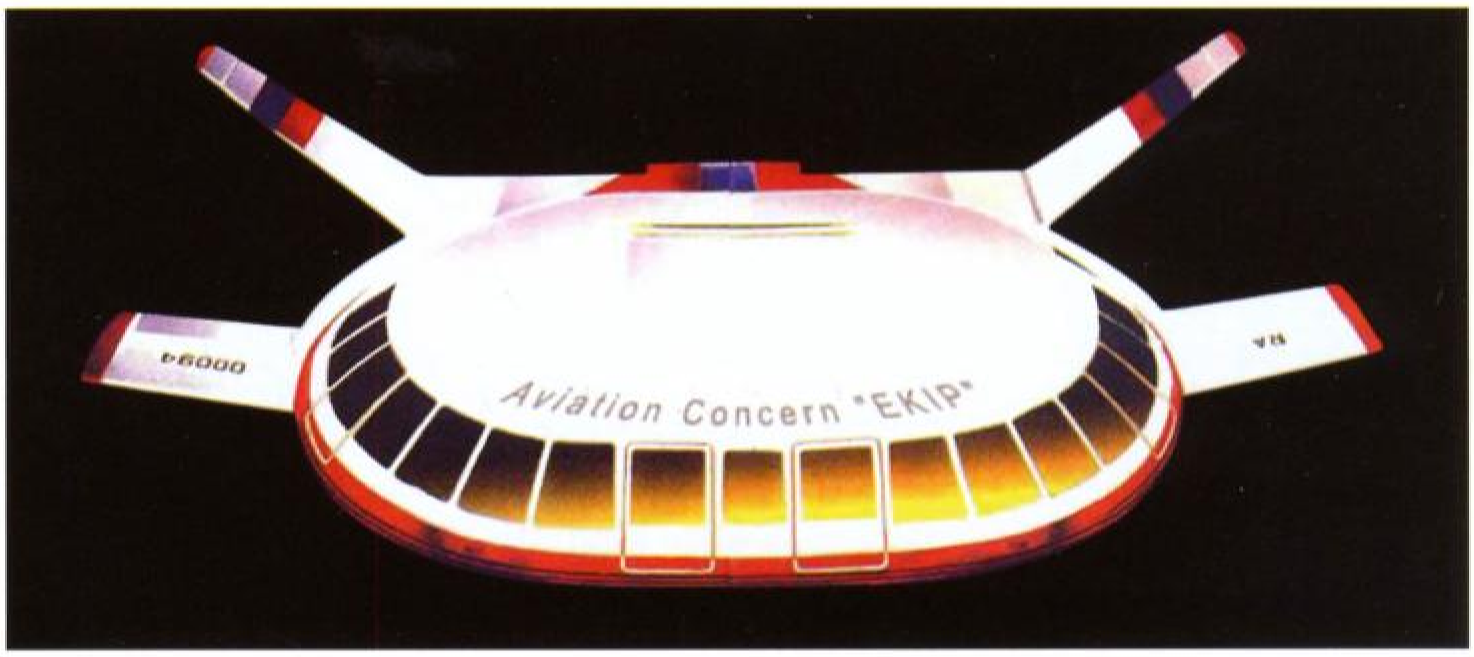


Fisheye lens view of the EKIP (Ekologiya i Progres – Ecology and Progress) vehicle developed by Professor Lev Nikolaevich Schukin and Alexander Sobko. EKIP

The EKIP test vehicle at the Saratov Aviation facility during the Mid-1990s. EKIP

A proposed passenger-carrying version of the EKIP vehicle. EKIP





unusual airframes with Saratov Aviation. NAVAIR would not expand on the reasons why this promising design had been dropped. Conceivably, there were engineering difficulties, or perhaps political considerations, that led to this decision.

The future of EKIP is uncertain and, while there could be fresh interest in Russia or China, the situation does not look very encouraging. As a military craft, EKIP might have been ideal for rapid-reaction military special operations, with the potential to replace large helicopters and some armoured vehicles. Relatively stealthy and able to transport more troops than a Chinook, an EKIP equipped with exotic directed energy weapons, and perhaps an electromagnetic railgun, might have created a small revolution on the battlefield. Of course, this assumes that the propulsion system could be made to work!

Chapter Six

Lighter-Than-Air Vehicles and the UFO Connection

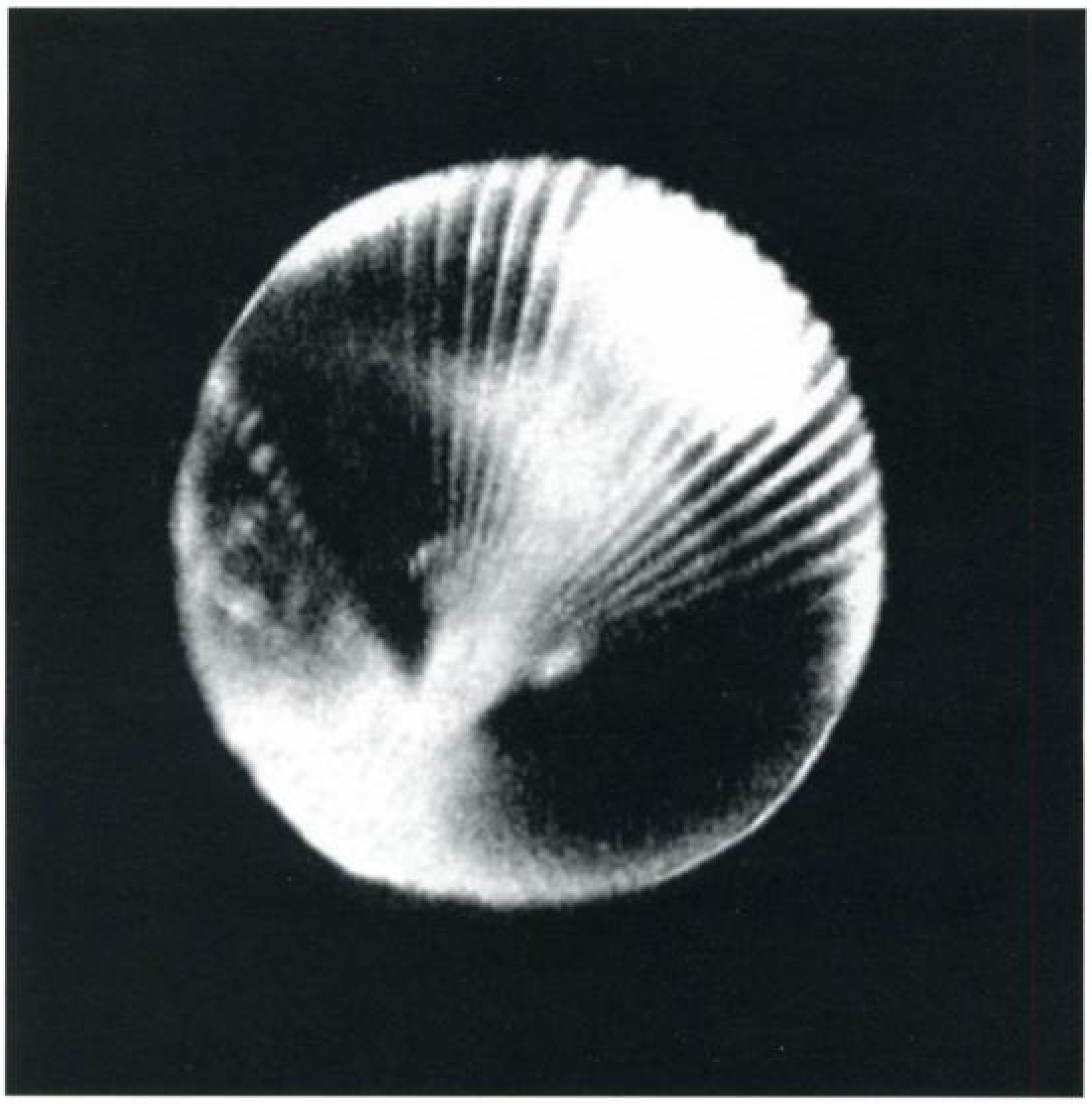
Balloons have been associated with UFOs since 1947 and two of the most widely publicised UFO incidents can be directly linked to US military balloon projects. The late 1940s was a time of international tension and growing concern in the West about Soviet intentions and their military capabilities. The Russians had captured a vast amount of advanced technology from the Germans and a deadly arms race was gaining momentum. Unfortunately for the West, gathering information from behind the Iron Curtain was proving enormously difficult.

MI6 and the CIA had some agents inside the Soviet Union and dangerous reconnaissance flights were occasionally undertaken that often ran the gauntlet of Russian fighter aircraft, but in reality these agencies had little idea what military developments were taking place. The Americans and the British were working on specialised high-altitude spy-planes, but this represented a clear technological boundary and space-based reconnaissance systems were something belonging to the more distant future. However, unmanned balloons presented a relatively inexpensive low-tech option and, although their capabilities were limited and performance somewhat hit-or-miss, the high-altitude balloon offered some intriguing possibilities.

Long before the first powered flight in 1903 manned balloons had been used for covert military operations. The Pentagon decided there was nothing to be lost by initiating several unmanned balloon projects, usually under the cover of meteorology studies. Eventually, this would lead to the large-scale deployment of balloons on long-range photo-reconnaissance missions across Soviet territory. Balloons were relatively inexpensive and, assuming sufficient numbers were launched, it stood to reason that the payloads carried by some might be recovered and a few would contain valuable photographic data. Specialist payloads might also be launched to gather electronic and acoustic data, or perhaps collect particles that would indicate a nuclear weapon test. With increasing numbers of large balloons being launched and often drifting across US skies for extended periods, it was inevitable that many of these flights would generate public reports of UFOs.

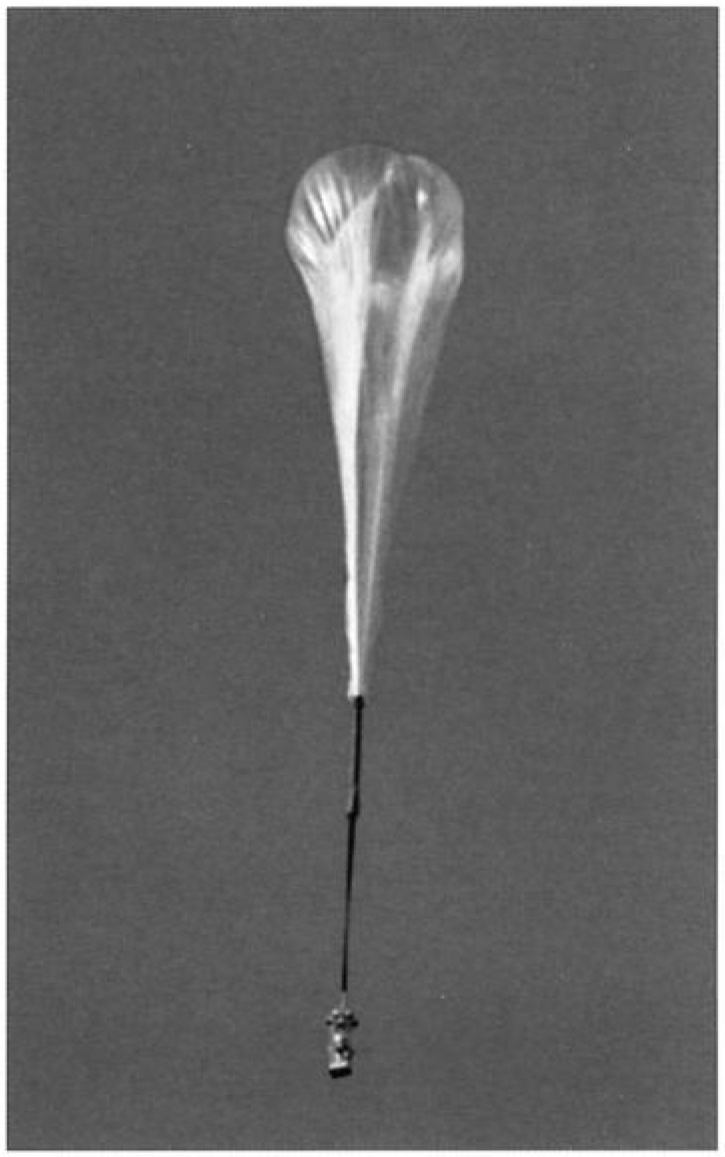
Skyhook

Under the broad designation Skyhook (not to be confused with Robert Fulton's aerial retrieval system of a similar name), the USAF and US Navy released many high-altitude bal-



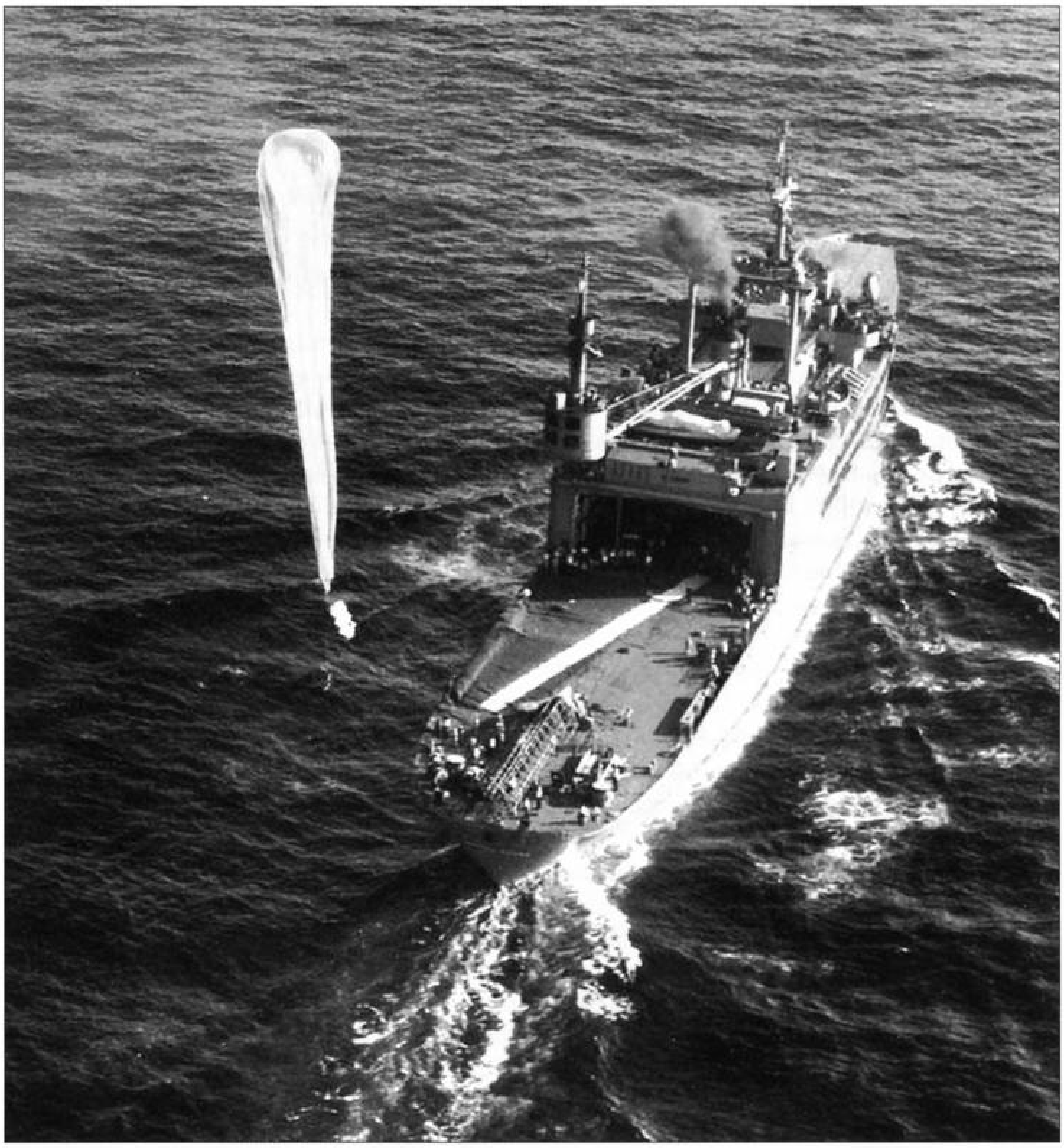
Above: **A Skyhook balloon seen from directly below, producing the impression of a circular silver UFO.** US Navy

Right: **Helium is pumped into a Skyhook balloon during the initial inflation stage, prior to launch from the US Navy aircraft carrier *Valley Forge* in 1960.** US Navy



loons during the early postwar years from various sites across the United States. These balloons were ostensibly for meteorological and scientific purposes and, while the specification for Skyhook balloons was variable, they were usually designed to achieve a constant level in the stratosphere and carry a useful payload for several days. The average Skyhook balloon had an approximate length of 75ft (22.9m) and a diameter of about 100ft (30.5m). Some larger balloons were produced for unusual missions with lengths in excess of 400ft (122m) and diameters of 300ft (91m).

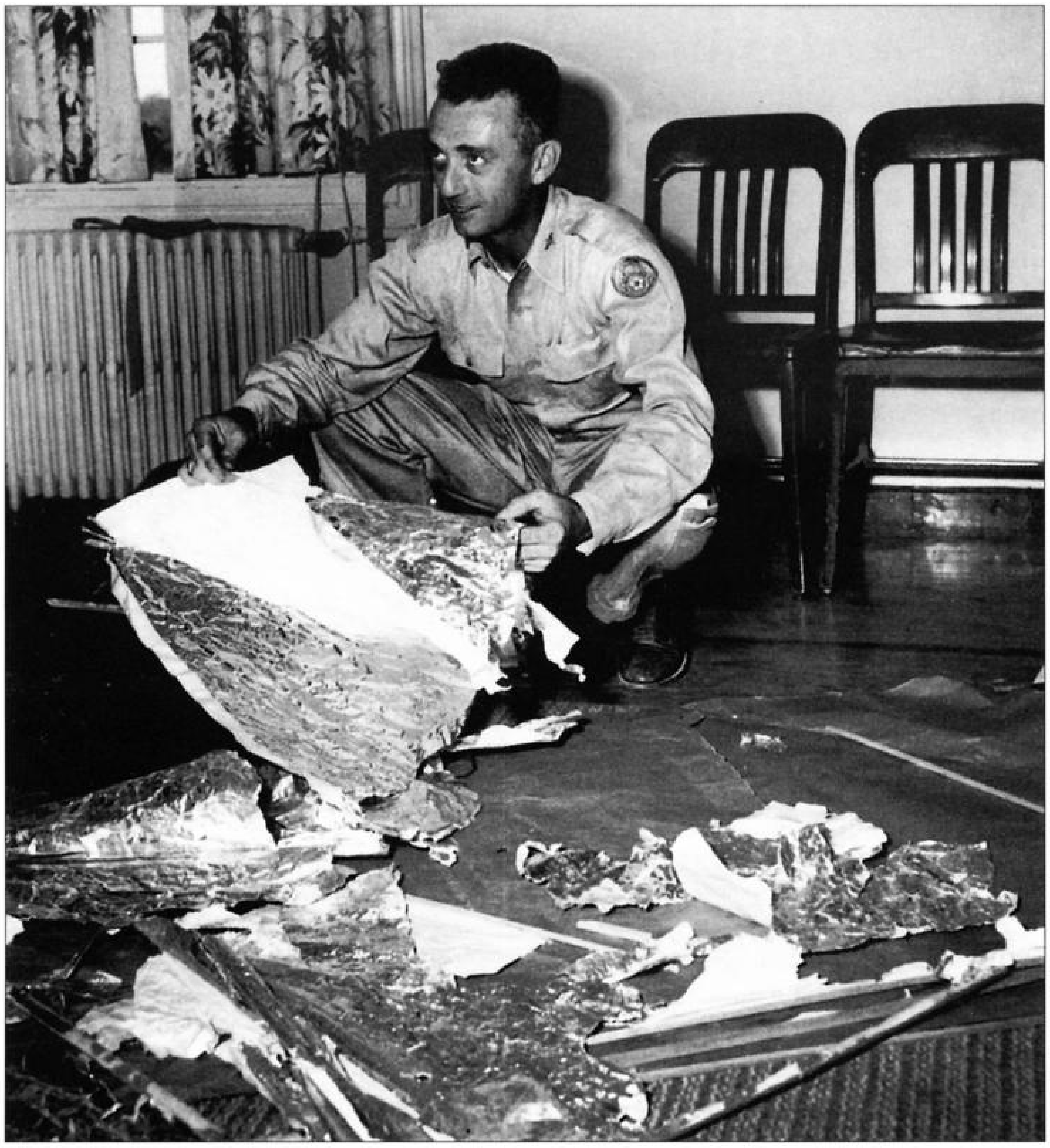
These relatively inexpensive enclosures were made from polythene and manufactured by the Aeronautical Research Division of General Mills; helium was always used as the lift gas. Under good atmospheric conditions their substantial size would make them visible at an altitude of 100,000ft (30,500m) or even higher, with an observable slant range in excess of 85 miles (136km) when conditions permitted. The balloons would be seen to alter colour during sunset and sunrise, which could be quite dramatic when viewed from



Top left: **A Skyhook balloon is prepared for launch from the deck of the US Navy Aircraft Carrier *Valley Forge* in 1960.** US Navy

Top right: **A US Navy Skyhook balloon shortly after launch.** US Navy

Right: **Skyhook balloon No 93 leaving the deck of USS *Norton Sound* (AV-11) on 31st May 1949.** US Navy



USAAF Intelligence Officer Major Jesse Marcel displays pieces of a weather balloon in General Roger Ramey's Office, which was allegedly recovered from the Foster Ranch near Roswell in June 1947. Following a poorly considered USAAF press release, there would be claims that the USAAF had recovered debris and perhaps crewmembers from a crashed alien spacecraft. When the USAF re-opened the case fifty years later, they suggested that a top-secret balloon project called Mogul was the reason for the cover-up. Many still doubt this is the real explanation. Fort Worth Star-Telegram Photograph Collection, Special Collections Division, University of Texas at Arlington Libraries

near-dark conditions on the ground. It is this particular feature that is thought to have generated many UFO reports. According to Project Blue Book, the USAF's UFO investigation bureau that operated at Wright-Patterson AFB from 1952 to 1969 and employed several eminent scientists as consultants, at least 21.3 per cent of all UFO reports could be directly attributed to balloons.

It now seems certain that a Skyhook balloon was responsible for the famous Mantell Incident of 7th January 1947. Drifting at an altitude of about 70,000ft (21,336m), it was observed by large numbers of witnesses across Kentucky and generally described as a UFO. Captain Mantell tried to intercept the unidentified object in his North American P-51 piston-engined fighter and broke regulations by climbing above 14,000ft (4,267m) without oxygen. He then lost consciousness at an estimated height of about 25,000ft (7,620m) and was killed in the subsequent crash. While this story has entered UFO folklore, scientific evidence, including meteorological data and telescope sightings by two different astronomers, appears to confirm the balloon explanation.

There were many suggestions that the balloon in question had been launched from Clinton County Air Base (now a commercial site) near Wilmington Ohio, but this seems incorrect because records show that no Skyhooks were released from this location before July 1951. However, Professor Charles B Moore, who headed the US Navy's Skyhook programme, said that this balloon undoubtedly originated from Camp Ripley, Minnesota on 6th January 1948 and that it was carrying cosmic ray detection equipment. Moore claimed that, after the event, the US Navy was reluctant to admit it had played any part in the death of a flyer and personnel were instructed not to discuss the matter.

From 1947 until around 1960 several hundred Skyhook balloons were launched from a wide variety of sites, carrying scientific payloads. Missions included cosmic ray detection and photography, such as the 1957 Stratoscope Project that provided the first high-quality images of sunspots using a 12in (30.5cm) telescope lifted to very high altitude by a balloon. The nature of some operations however, especially those conducted by the USAAF/USAF from Alamogordo Army Airfield (later Holloman AFB), New Mexico, remain less clear – while the balloons themselves were not classified it seems that many of the payloads were. Some balloons undoubtedly carried experimental photographic equipment intended for future use in high-altitude spyplanes like the Lockheed U-2, and several large balloons lifted payloads in excess of five tons to altitudes above 100,000ft (30,500m).

The names for these secret development projects included Grandson and Greyback, which would lead to the Genetrix programme. The USAF and US Navy undertook balloon releases right across the country, from locations within states such as New Mexico and Colorado to New Jersey and New York, and many of the balloons launched in the Western States drifted across the whole of America. At high altitudes the huge lightweight envelope would lose its shape, often becoming spherical, oval or disc-like, and perhaps slowly shifting in appearance and glowing in unusual colours as the balloon's polythene picked up sunlight no longer visible from the ground. It is therefore hardly surprising that the public reported many of these objects as UFOs during a period of intense interest in the subject.

Project Mogul

In late 1945 US Intelligence learned that the Soviets had started a crash programme to build an atomic bomb and concerns began to be voiced about the issue of detecting a Soviet nuclear explosion. Although the first Russian test was not anticipated before early 1950, Lewis Strauss of the Atomic Energy Commission raised the question of long-range detection in April 1947. His concerns were taken seriously by the Central Intelligence Group (the initial name for the CIA), who formed a committee during May 1947 to investigate ways to gather information.

One possibility they discussed was a top-secret experimental balloon programme that was given the codename Project Mogul. Little documentation has survived but Project Mogul is still described by the USAF as a highly compartmentalised part of the NYU (New York University) balloon programme, which was based on research carried out by Dr Maurice Ewing at Columbia University, NY, during 1945. Project Mogul balloons were intended to carry Top Secret low-frequency acoustic detection equipment to high altitudes and listen for possible Soviet nuclear test explosions.

During World War Two Dr Ewing had become interested in the idea of underwater sound channels and had already managed to detect distant underwater explosions using submerged microphones. He theorised that there might be a similar sound channel in the upper atmosphere that could be utilised by equipment carried under a balloon. Sponsored by Air Material Command (AMC), contracts were secretly issued to Columbia University for the development of electronic hardware (AMC contract W28499-ac-82) and to New York University (NYU) to devise a suitable constant-level balloon (AMC contract W28-099-ac-241).

A typical Project Mogul balloon system was formed from twenty-eight neoprene meteorological balloons linked by a 600ft (183m) nylon cord. This balloon train, and its automatic ballast system, was developed by Professor Charles B Moore, who acted as the project's engineer. The Mogul train carried an assortment of electronic equipment that included a sonobouy microphone, amplifier, radio transmitter and a power pack. There were also ballast containers and three ML-307B Rawin radar targets attached to assist with tracking. Rawin is short for radar wind. Small neoprene balloons carried these radar reflectors for the purpose of measuring wind speed.

Project Mogul test flights were undertaken at Alamogordo AAF (Holloman AFB) in New Mexico during June and July 1947. However, Project Mogul never progressed beyond this phase and the first Soviet nuclear test was confirmed by the Americans and British during September 1949, when airborne radioactive particles were gathered by aircraft using techniques developed by Tracelab in 1948.

During 1994 public concerns about the mysterious Roswell Incident were taken up by Congressman Steven Schiff. He approached the USAF and met with considerable resistance, so Schiff used the General Accounting Office (GAO) to force them to explain the event, which was perceived by some as the crash of an alien spacecraft near Roswell, New Mexico in 1947. A USAF investigation team headed by Colonel Richard Weaver started their enquiry by analysing all the best-known literature on the Roswell Incident. They eventually came up with the theory that an early Project Mogul service flight (Number Four launched on 4th June 1947) might have been responsible. It was suggested that the Mogul balloon train had been caught by unusual winds and subsequently carried to the Foster Ranch where it came to rest and was discovered by Mac Brazel.

This met with ridicule from the UFO community and after further lengthy deliberations, the USAF released a second report on 24th June 1997 called 'The Roswell Report: Case Closed', which reaffirmed the Project Mogul balloon theory. Many aspects of the story remain shrouded in mystery and the USAF were unable to explain why the recovery of a balloon carrying primitive acoustic sensor equipment would need to be hidden behind a wall of impenetrable secrecy for half a century. The debate continues and the Pentagon only has itself to blame for allowing whatever happened to build into a legend.

Genetrix

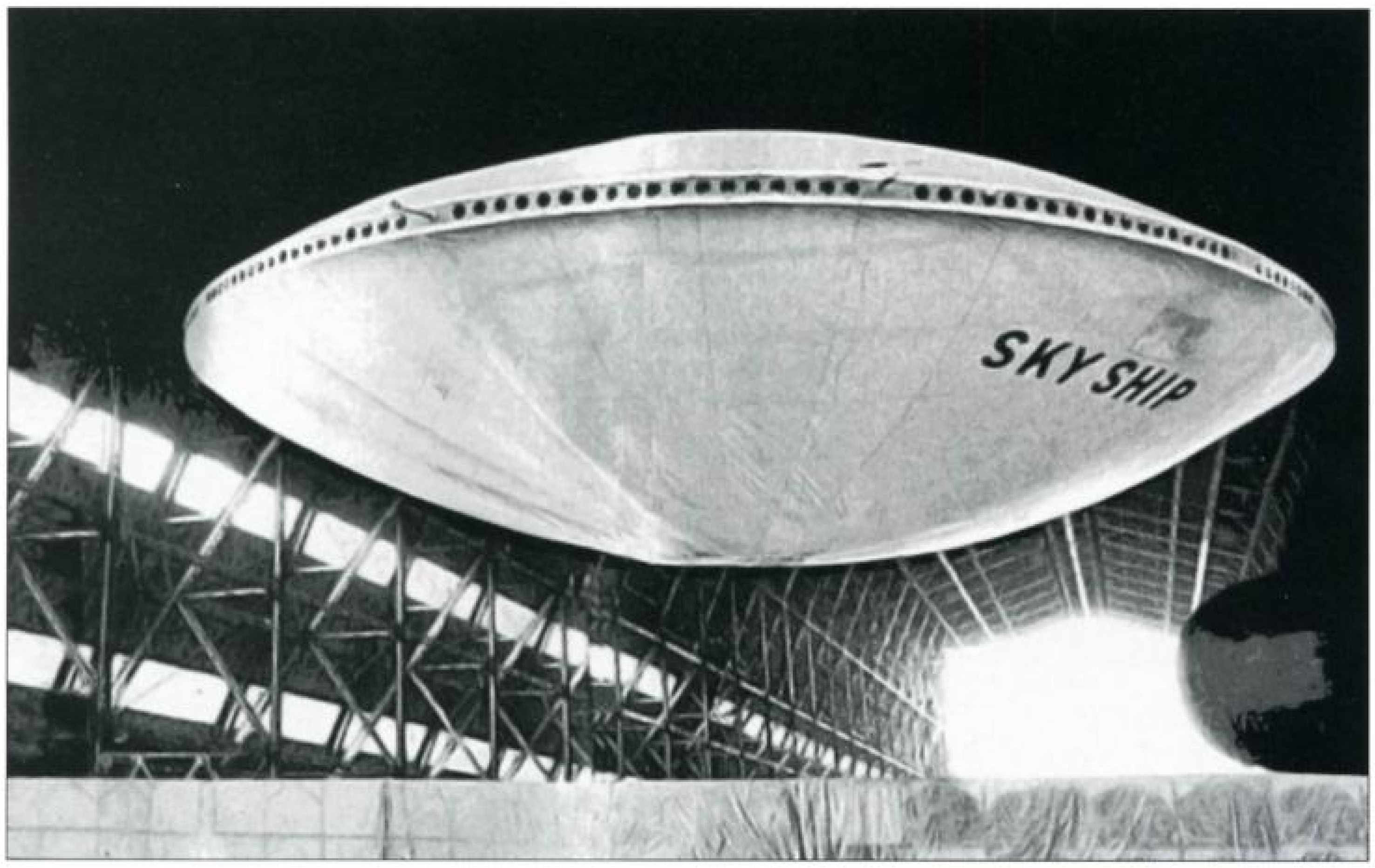
On 27th December 1955 President Eisenhower authorised a top secret CIA project called Genetrix that would involve the launching of camera-carrying balloons that would drift across the Soviet Union taking pictures from an altitude of 72,000ft (21,946m). Under good daylight (or moonlight) conditions they would be highly visible from the ground, but the balloons would be hard to track with radar and almost impossible to intercept by any prevailing means. The launch sites were in Scotland, Norway, West Germany and Turkey. Those balloons that made it across Russia were recovered in mid-air above the Pacific by a specialised C-119F aircraft operating from Japan or Alaska. An encrypted radio signal from the aircraft released the camera package, which would descend by parachute allowing capture by the aircraft. This was potentially quite a dangerous undertaking!

During the programme, a totally unexplained and seemingly irrational decision was taken by Pentagon officials to lower the operational ceiling of these balloons to 55,000ft (16,764m) and this made it much easier for the Soviets to take action against them. Some 516 Genetrix balloons were released before diplomatic pressure from the Kremlin forced the Americans to stop. The technical value of this operation remains questionable as only forty-six capsules were recovered. Of these, several malfunctioned while others recorded images of no intelligence interest, which left about thirty-four useful payloads.

Unmanned high-altitude US balloons undertaking photo-reconnaissance missions above the Soviet Union were initially beyond the reach of Russian air defence measures. Bill Rose

Another highly classified US balloon programme was started in 1957 with the designation WS-461L Melting Pot. This operated from much higher altitudes, carried a more sophisticated camera package and had the potential to circle the globe in one month, maintaining a height of 100,000ft (30,500m). Melting Pot's main payload was the Itek HYAC-1 large format roll-film panoramic camera, developed under the direction of Itek's Chief Engineer Frank Madden. This newly designed state-of-the-art unit with its f/5 305mm lens provided a 120° field of view and was capable of capturing very high resolution images (in excess of 108 lines per millimetre).

After a series of trials seven WS-461L balloons were launched from the US aircraft carrier *Windham Bay* during July 1958. To enhance the secrecy of this operation, the first four carried simple meteorological payloads and these were followed by three reconnaissance versions (S-430, 431, 432) lifting their Itek camera packages. However, a series of problems arose and these balloons' gondolas were released over Poland, handing the Soviets a major political coup. At a stroke the Americans had given the Russians their most sophisticated intelligence-gathering hardware on a plate, while generating a serious international incident. This brought the unmanned reconnaissance balloon pro-



Skyship was a British flying saucer-shaped airship built at Cardington and completed during April 1975. Intended to be the scale prototype for a much larger series of vehicles, the project never advanced any further. via Bill Rose

gramme to a complete standstill, although there is evidence that limited CIA balloon missions continued throughout the remainder of the Cold War.

Skyship

Built at Cardington, England and completed in April 1975, Skyship was a prototype flying saucer-shaped airship with a diameter of 30ft (9.1m). Designed by John West, it was hoped that trials of this substantial model would lead to the commissioning of a much larger 200ft (61.0m) diameter manned craft capable of carrying a 10-ton payload. West believed that the lenticular shape would negate the effects of ground winds and it was ideal for good load distribution. Propulsion would be by means of vectorable, ducted fans. Beyond this West envisaged an even larger Skyship capable of transporting 400-ton payloads across unrefuelled distances of 1,000 miles (1,600km) at speeds of 100mph (160km/h). He hoped it would be ideal for use in developing countries as an inexpensive transporter, but there were no takers and the Skyship demonstrator was never developed further.

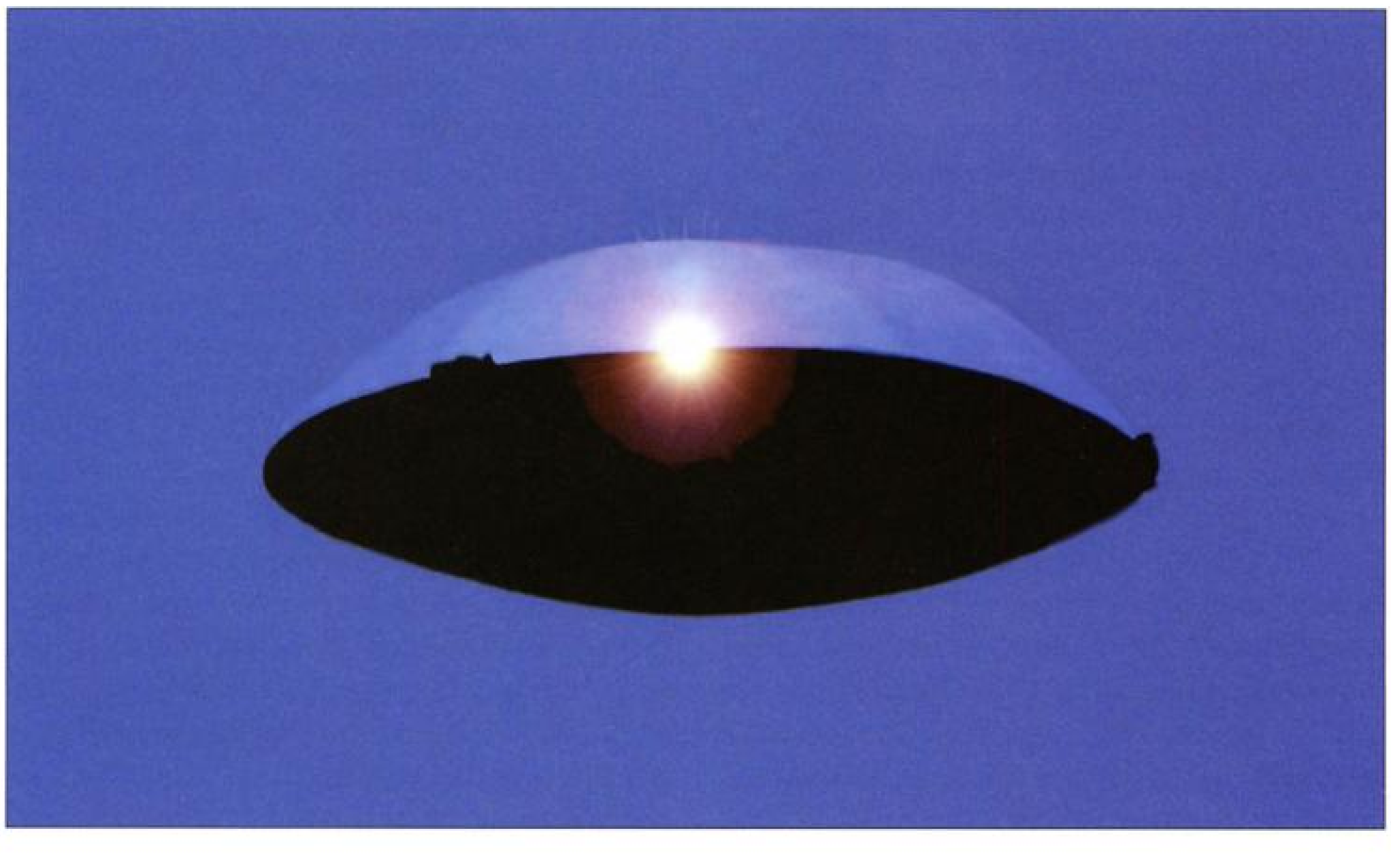
The Channel 4 TV Flying Saucer Hoax

On 16th August 2003 a production company working for Channel 4 Television in the UK undertook an extremely elaborate flying saucer stunt and it was shown as a documentary called *A Very British UFO Hoax* on 7th October of that year. The project had begun in late 2002 when Mark Raphael, an executive producer with Chrysalis TV, came up with several ideas for an audacious flying saucer hoax. It is thought that he was inspired by Virgin boss Richard Branson's notorious 1989 April Fool's Day stunt, which had involved a carefully designed hot air balloon that looked like a UFO. Raphael's idea was to construct a convincing flying saucer, fly it across an area know to be of interest to the UFO community, and record the effects on local observers.

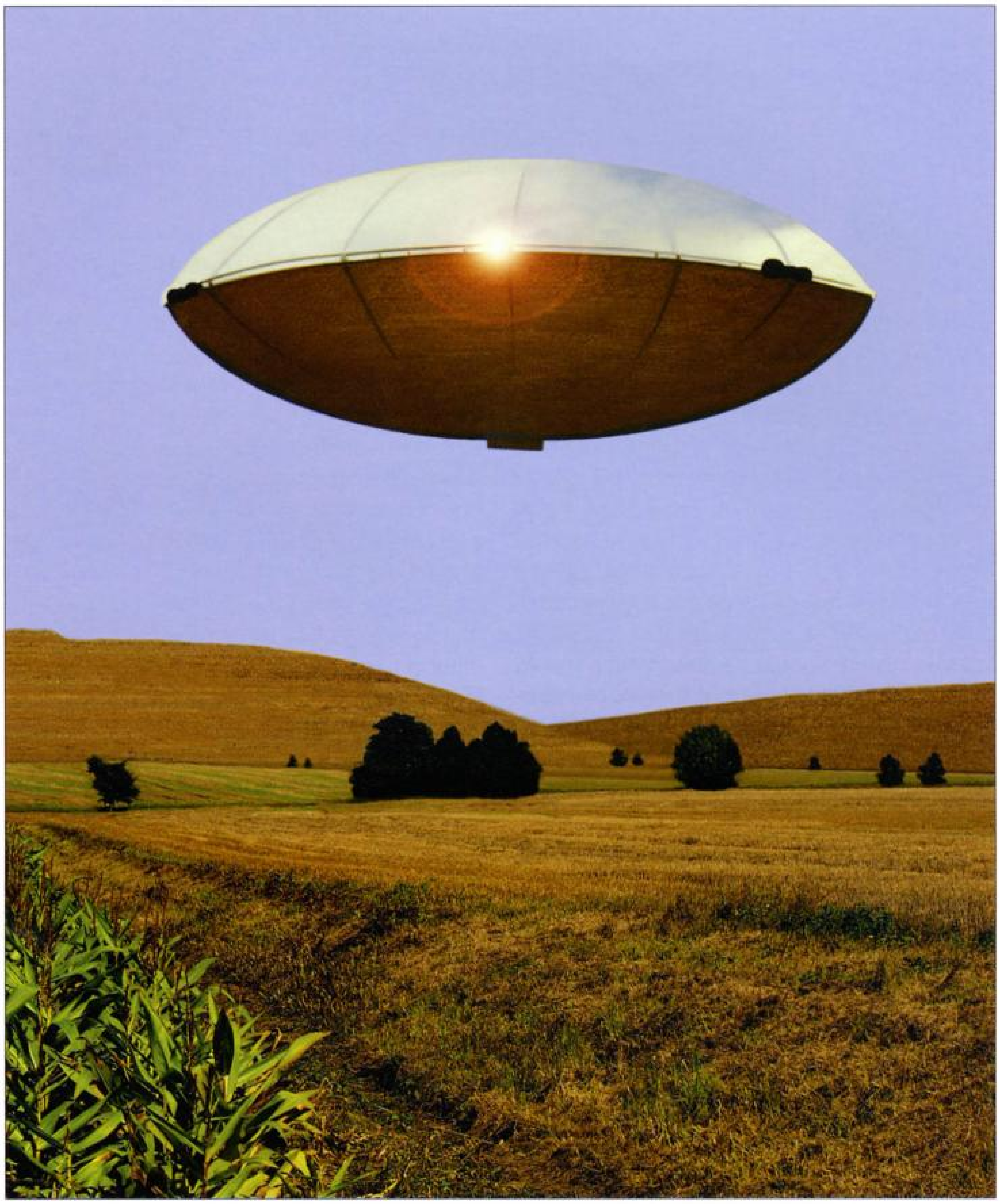
Once the plan had been developed into a realistic proposal, Channel 4 TV was approached to sponsor a sixty-minute documentary with the working title *How To Build a Flying Saucer*. Impressed by Raphael's idea, Channel 4 commissioned the programme and Chrysalis immediately signed up Cutting Edge Effects Ltd to build and operate a convincing remote-controlled flying saucer. This UK special effects company based at Elstree Studios, Borehamwood, had been involved with many big-budget productions that stretched from Bond films like *Goldeneye* to major TV productions such as *Band of Brothers*. Handling the technical side of this flying saucer project were leading industry experts Robbie Scott and Nigel Blake. After initially discussing the project with Raphael, Scott agreed to an eight-month development period and apparently quoted Chrysalis a figure of around £50,000 for the package. Scott and Blake had several ideas about the kind of craft needed for the project but, after reviewing a considerable amount of UFO footage and studying hundred of images, they settled on a fairly classic flying saucer shape.

In appearance this design was fairly similar to John West's mid-1970s scale-sized demonstrator of his Skyship project. Cutting Edge's lighter-than-air model would be built around a simple carbon fibre hoop that dismantled into eight separate sections, while two separate bags of helium would be used to maintain buoyancy. A skin of lightweight reflective material would then cover the model, hopefully providing the illusion of a solid vehicle. The craft would have a diameter of about 25ft (7.62m) and a central thickness of between 8ft and 10ft (2.4m and 3.0m).

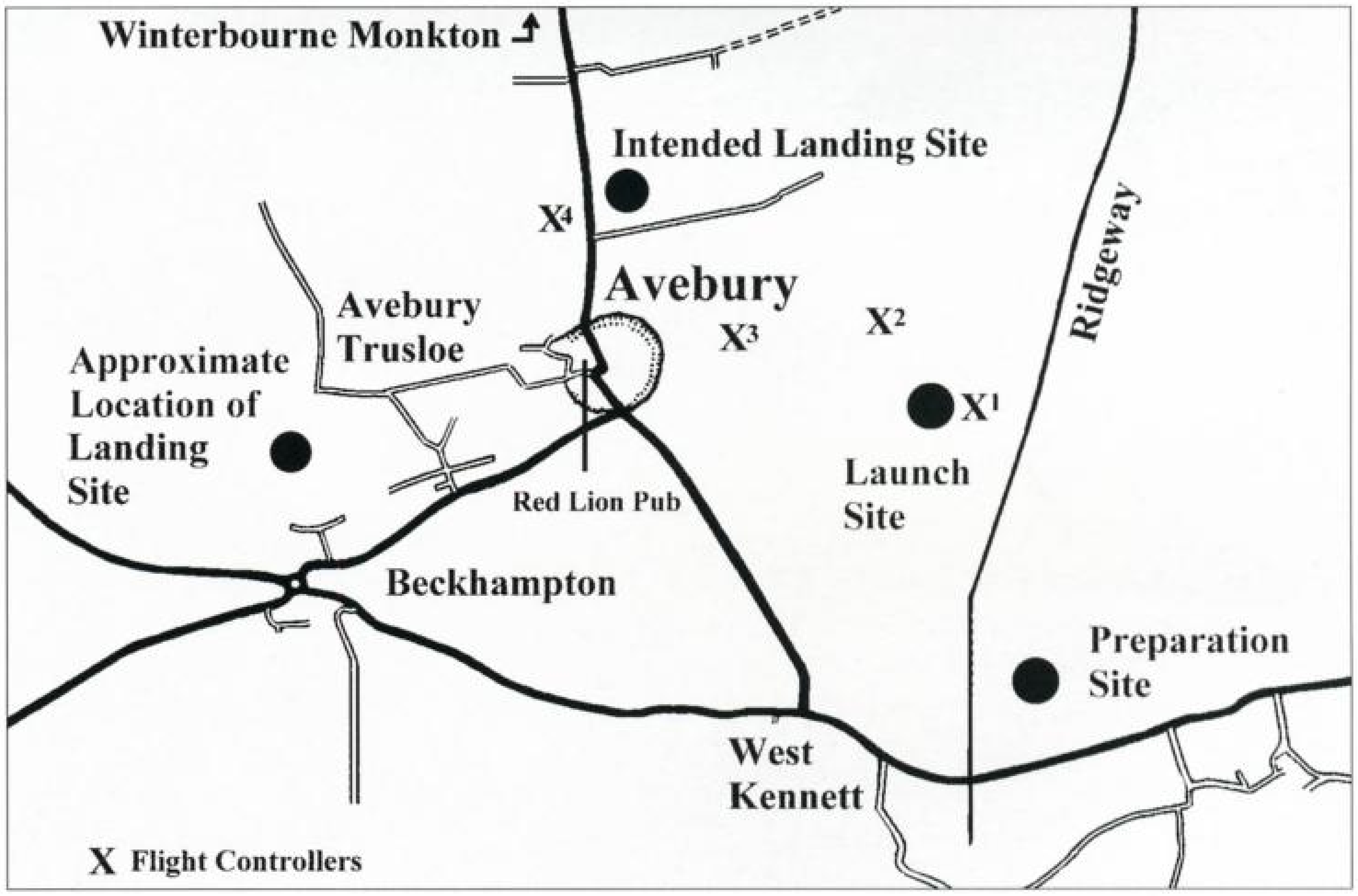
Cameron Balloons Ltd, based in Bristol, were approached to assist with this part of the project and they suggested a Silver Helium envelope to fit the carbon fibre hoop, which



Simulation of the Chrysalis flying saucer, built by film industry special effects company Cutting Edge Effects for the TV Production 'A Very British UFO Hoax'. Bill Rose



Right: **Illustration of the Chrysalis/Cutting Edge flying saucer model passing over the Wiltshire countryside.** Bill Rose



Below right: **Map of Avebury, showing planned and actual launch/landing sites.** Bill Rose

would contain the lift gas. As a result of these preliminary discussions an envelope was produced from approximately 984ft (300m) of a helium fabric composite material (with a silver Mylar laminate) and it was assembled using Cameron's sewn/sealed technique. Initial experiments under the direction of Cameron's Gas Department Manager Gavin Hayles went well, but there were problems with the flying saucer's appearance caused by noticeable wrinkles in the Mylar. Visually this was unacceptable and it might have ruined the stunt, so considerable effort was made to smooth the surface.

This was followed by compatibility problems with the small German-made fans that had been supplied for use with the ducted-fan propulsion units and further delays with delivery of the model's power source. As a consequence Robbie Scott travelled to California and collected the 5kW electric generator from the manufacturer. However, when Cameron Balloons delivered the Silver Helium skin in late July 2003, it weighed 79 lb (35.8kg), which meant that the craft was now overloaded by about 24 lb (10.9kg). Because of this weight problem the generator had to be abandoned and replaced with a power pack using nickel-cadmium batteries wired to each motor. Further weight reduction measures took the form of holes drilled in the carbon fibre hoop.

Although the switch to battery power was less satisfactory, it would be possible to attain a maximum speed of 20mph (32km/h), although the range would be somewhat reduced with tests indicating that the batteries would be completely exhausted after twenty minutes in the air. A radio control unit was finally installed on the internal equipment platform, which could be accessed via a small tunnel when the envelope was inflated. This control system was linked to each ducted fan unit via a network of fibre optic cable and the saucer was ready to be secretly tested at RAF Aston Down, which is a largely disused World War Two military airfield situated between Stroud and Cirencester.

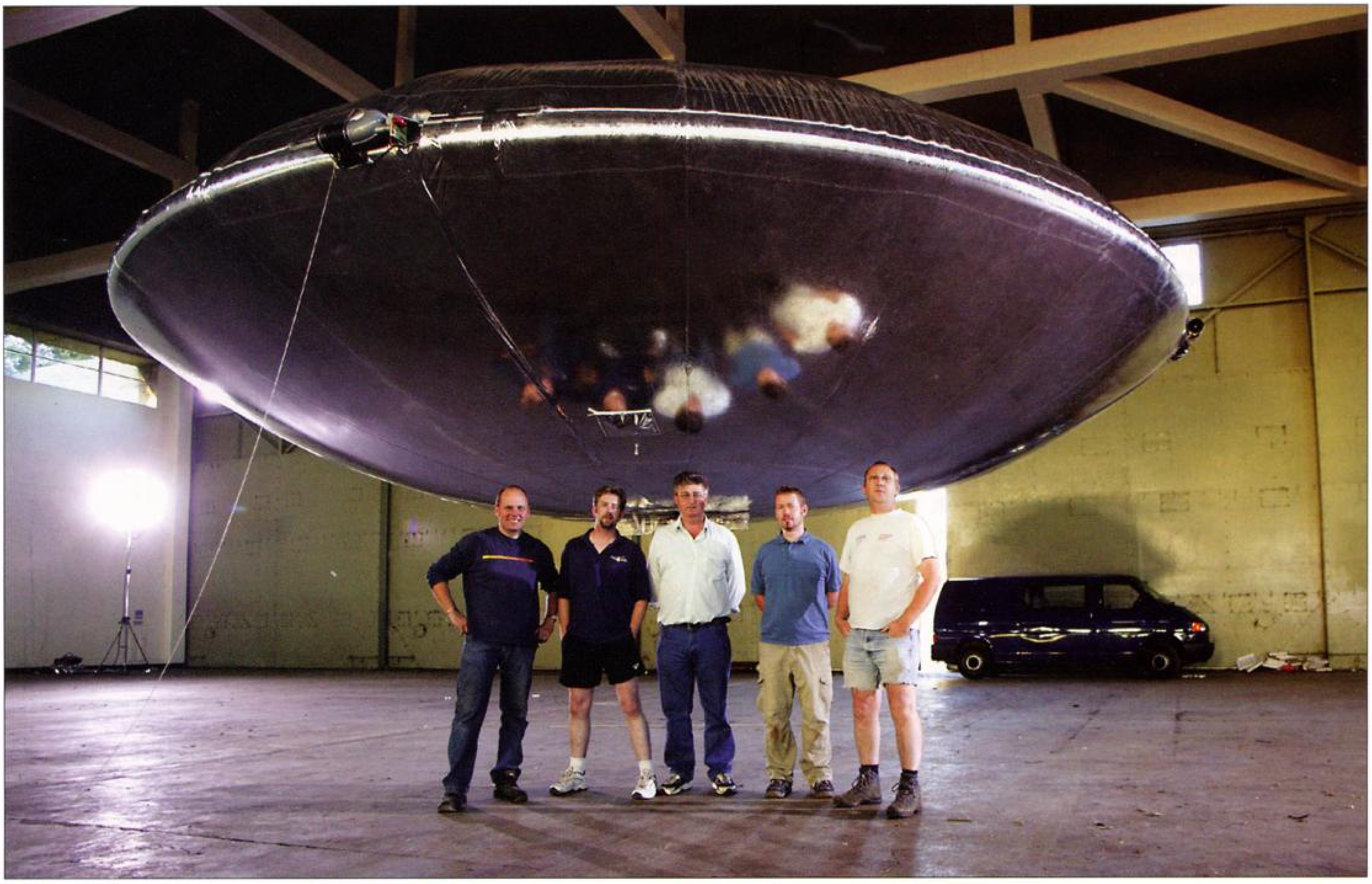
The next stage was certification by the Civil Aviation Authority (CAA), which was represented by John Greenfield, a respected name in the model aircraft field. Cutting Edge had brought in John Palmer, a leading model aircraft flyer, to take charge of flight operations and demonstrate to Greenfield that the operation could be conducted safely. Palmer decided they would need five to seven pilots with a backup and once this had been established they set about demonstrating the flying saucer to Greenfield. Unfortunately there were serious stability problems and it was almost impossible to control pitch during tethered flights inside the large hangar. This was finally overcome by the attachment of a small cardboard spoiler beneath the craft, which fully counteracted the difficulty. The spoiler was later replaced by a slightly more refined version covered in reflective film.

Once Greenfield was satisfied that the model could be properly guided by all the operators, an Air Navigation Order and Exemption Certificate was issued, which limited the ceiling to 400ft (122m) and specified a visual control range not exceeding 1,640ft (500m). Another condition stipulated that an automatic fail-safe system should be fitted which would force the vehicle to land in the event of a control system failure and it was agreed that local air traffic controllers would be informed of the flight prior to it taking place.

While work had been progressing on the flying saucer, Robbie Scott and Chrysalis Producer Chris Harries were completing their survey of suitable locations for the hoax. The most favoured location was Rendlesham Forest in Suffolk, close to the now defunct USAF Bentwaters base. This had been the scene of a very controversial UFO encounter on 27th December 1980, which is still regarded as Britain's Roswell Incident by many members of the UFO community. However, there were many specific problems with this location that included flying restrictions within military airspace, so attention soon switched to the second choice, which was Avebury, Wiltshire, just a few miles north of Salisbury Plain. This village is internationally famous for its mysterious stone circle dating back to around 2,500 BC and the entire area has a reputation as something of a hot-spot for paranormal events, crop circles and UFO sightings, making it a great location to stage a flying saucer hoax.

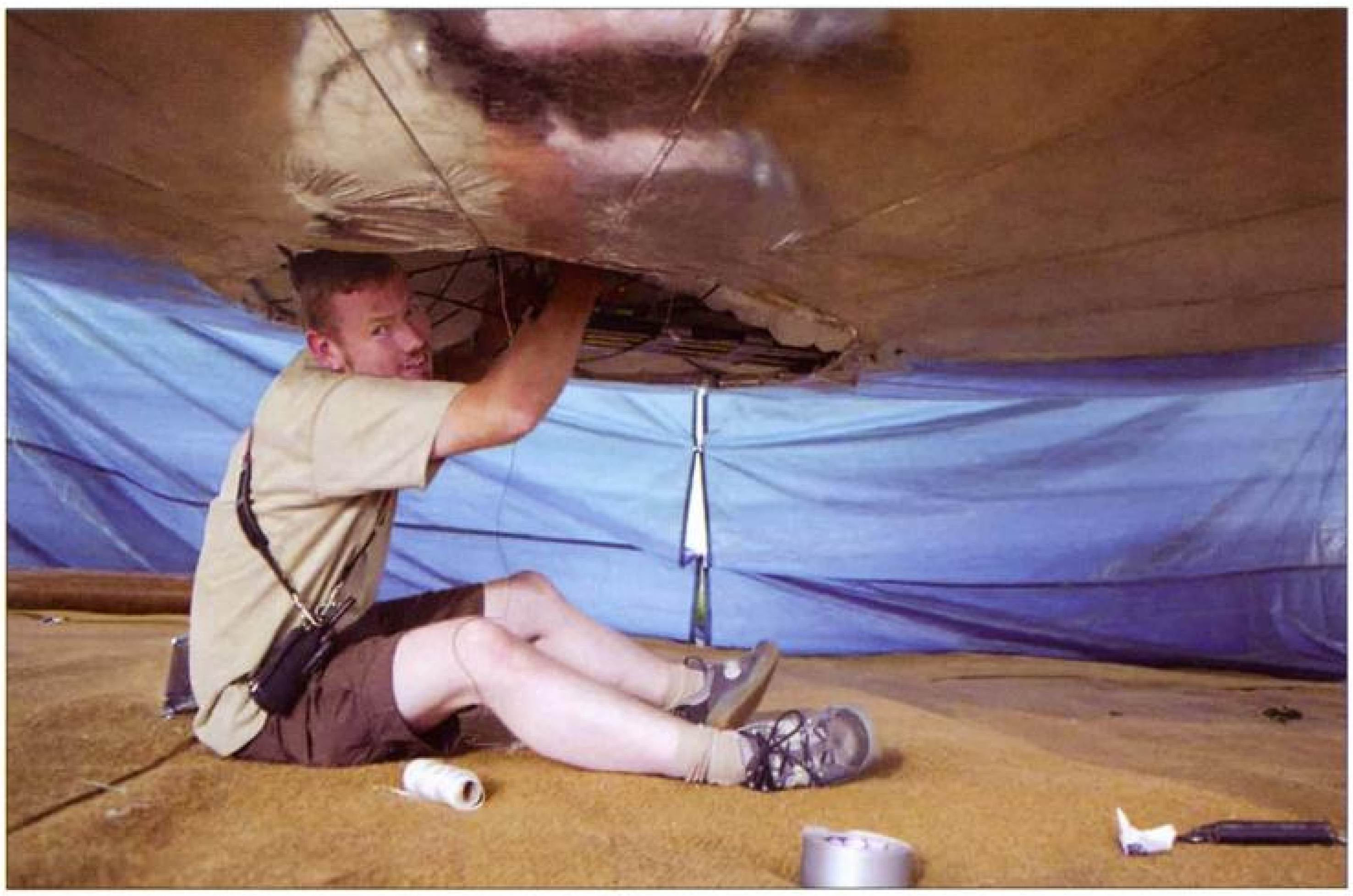
In June 2003 Harries contacted Brian James, the former chairman of the British UFO Research Association (BUFORA), who runs a local group of UFO investigators called the Anomalous Phenomena Research Agency (APRA). Harries asked James if APRA members might be interested in participating in a TV documentary that was under development called The Believers and said he had been in contact with several other UFO organisations. According to James the sole objective behind this contact was to establish when the group would meet up at the Red Lion pub in Avebury to conduct one of their UFO sky watches.

Having learned that the APRA skywatch party was scheduled for 16th August, the Chrysalis production team appear to have made a decision to proceed with the flight on that date, hoping to capitalise on APRA's presence. When the day finally arrived most of the Chrysalis team gathered in a secluded farmer's field about two miles (3.2km) south-east of the village and just beyond the Ridgeway near Overton Hill. There was adequate cover to hide preparations from any preying eyes and the saucer was inflated beneath a canopy while the camera crews and flight controllers received further briefings. But a serious problem arose concerning the wind, which had been predominantly southwesterly during all the scouting missions but was now blowing in an easterly direction. Furthermore, there were concerns that the wind



The Chrysalis flying saucer during tests. The Cutting Edge Effects team line up below the model.
Nigel Blake

Final checks on the control system for the Chrysalis model flying saucer at Avebury, prior to launch. A small tunnel in the underside of the craft provided access to the equipment while the craft was inflated. Nigel Blake



speed might soon become too high, with a prohibitive limit of 5mph (8km/h) imposed by the CAA. Because of this Robbie Scott made some alterations to the flight path so the saucer would pass closer to Avebury and the flight time would be considerably reduced.

Once the model was fully prepared it was carried by members of the team about one mile (1.6km) from the operations site to a new position closer to Avebury. It would fly towards the village, briefly hover above a flat area of ground and then swing north to a concealed recovery point, accessed from the Winterbourne Monkton Road. Although the route taken to the launch site was fairly well hidden the reflective saucer could be seen at some distance, so it was covered with military camouflage netting during transit. One final problem arose with a fan, but this was easily fixed and the launch team waited patiently for confirmation that all the flight controllers were in place and ready.

With twilight fast approaching and the wind speed at an acceptable level, the saucer gently lifted away as world champion model aircraft pilot Steve Elias took control. As the saucer headed towards Avebury, control was passed to Steve Ansell and then John Palmer who were waiting in concealed positions along the Wessex Ridgeway. The model saucer glided across the Wiltshire countryside propelled by the battery-powered fans at a height of about 200ft (61m) and this provided some very pleasing visual images for the concealed camera crews.

Sitting outside the Red Lion public house were four unsuspecting APRA Skywatch members – James Hill, Tim Field, Jason Hawkes and Brian James. When the flying saucer came into sight at about 8.50pm a member of the Chrysalis production team appeared outside the pub and tried to generate excitement by drawing everyone's attention to the model saucer as it approached Avebury. According to the APRA members it was fairly obvious that the flying saucer was some kind of a balloon, which struggled to remain steady on the breeze while the noise from several electric motors could clearly be heard.

Having been visible for four to five minutes, the flying saucer finally passed over the village, its rim-mounted flashing LEDS and spotlight clearly visible. Brian James later commented, 'At no point were we remotely fooled by this remote-controlled balloon, but I do admit that we (APRA) were guilty of dismissing the event as a student prank rather than a highly organised and expensive stunt devised and executed by a professional film company'. While many onlookers moved away from the vicinity of the pub to gain a better view of the flying saucer, a film crew using amateur digital camera equipment arrived, fronted by Sean Doherty who was the production team's producer. Doherty undertook interviews with some of the observers, claiming that they were part of a small Marlborough or Swindon-based company who were in the area by chance. Aside from the APRA members, most witnesses reacted in a predictably rather startled manner and, in common with many UFO incidents, these observers were unable to gauge the size of the craft, with one estimate suggesting it was 100ft (30.5m) in diameter.

The altered flight route had taken the saucer towards the west and it was no longer possible to reach the intended landing site. Nigel Blake and an assistant had positioned themselves along the Winterbourne Monkton Road near the intended landing site and they immediately chased after the model in their van as it headed west. After travelling for a total distance of about 3 miles (4.8km) the model was finally brought down in a field near Avebury Trusloe by the last controller who activated the dump valve. Blake and his colleague now had to negotiate their way through a herd of cows in the gathering gloom to recover the model, disassemble it as quickly as possible and stow the parts in their van.

With the stunt completed, Chrysalis had plenty of useful video footage in the can, which looked visually very impressive. Apparently, a major production meeting took place on 23rd September at Chrysalis's office and a decision appears to have been taken to remove APRA's presence at the Red Lion. It is also possible that the idea of mounting a more elaborate UFO stunt in America was discussed, although nothing came of this. By now, the story had appeared on British and foreign TV news channels and in several newspapers, with the broadcast of *A Very British UFO Hoax* by Channel 4 TV taking place on 7th October.

As a piece of film-making the idea worked well. The production was slick, visually interesting and occasionally quite amusing. As a hoax there were some obvious problems and the altered flight path brought the saucer much closer to the Red Lion than originally anticipated. Because of this the noisy fans reduced the credibility of an otherwise well-planned and carefully executed project. The degree of directional control over this model is also questionable, as the model failed to reach the intended landing site and this was almost certainly caused by the use of a less efficient power source. Nevertheless, considering the brief amount of time allowed for design, construction and testing, this was a very impressive effort by Robbie Scott, Nigel Blake and their special effects team. Asked about building another flying saucer model, Nigel Blake believes it would be possible to refine the model considerably, improving many aspects of the design including its control, endurance and noise level. Since the programme was shown, Cutting Edge Effects Ltd has ceased trading with the technicians deciding to work independently, and Chrysalis Television has become North One Television.

Flying Saucer Spacecraft

The flying saucer is often perceived as the ultimate design for a space vehicle and since the mid-1960s this shape has been heavily promoted by the TV sci-fi series *Star Trek*, with its various Starship Enterprise configurations initially designed by Matt Jeffries (1921-2003). All versions of this fictional spacecraft have taken the form of a huge saucer-shaped body attached to a fuselage section (NX-01 has two linked booms) with twin tail fins and warp engine nacelles. While these elegant concepts are visually very pleasing the disc shape has little obvious value for a vehicle built to undertake deep space operations, although a wheel of sufficient size could be used to create an artificial gravity environment.

Having said that, the lenticular or heel-shaped vehicle is well suited to aerobraking or aerocapture through a planet's outer atmosphere and controlled descent to the surface. This profile allows a good distribution of heat and stress across the shielded area, making the circular shape preferable to a winged vehicle (like the US Shuttle Orbiter) during re-entry. But there are difficulties launching large circular-shaped spacecraft with conventional rocket boosters that have dissuaded military and civil space agencies from using this shape for manned vehicles, although small aeroshields employed for braking are now a common feature with unmanned planetary probes.

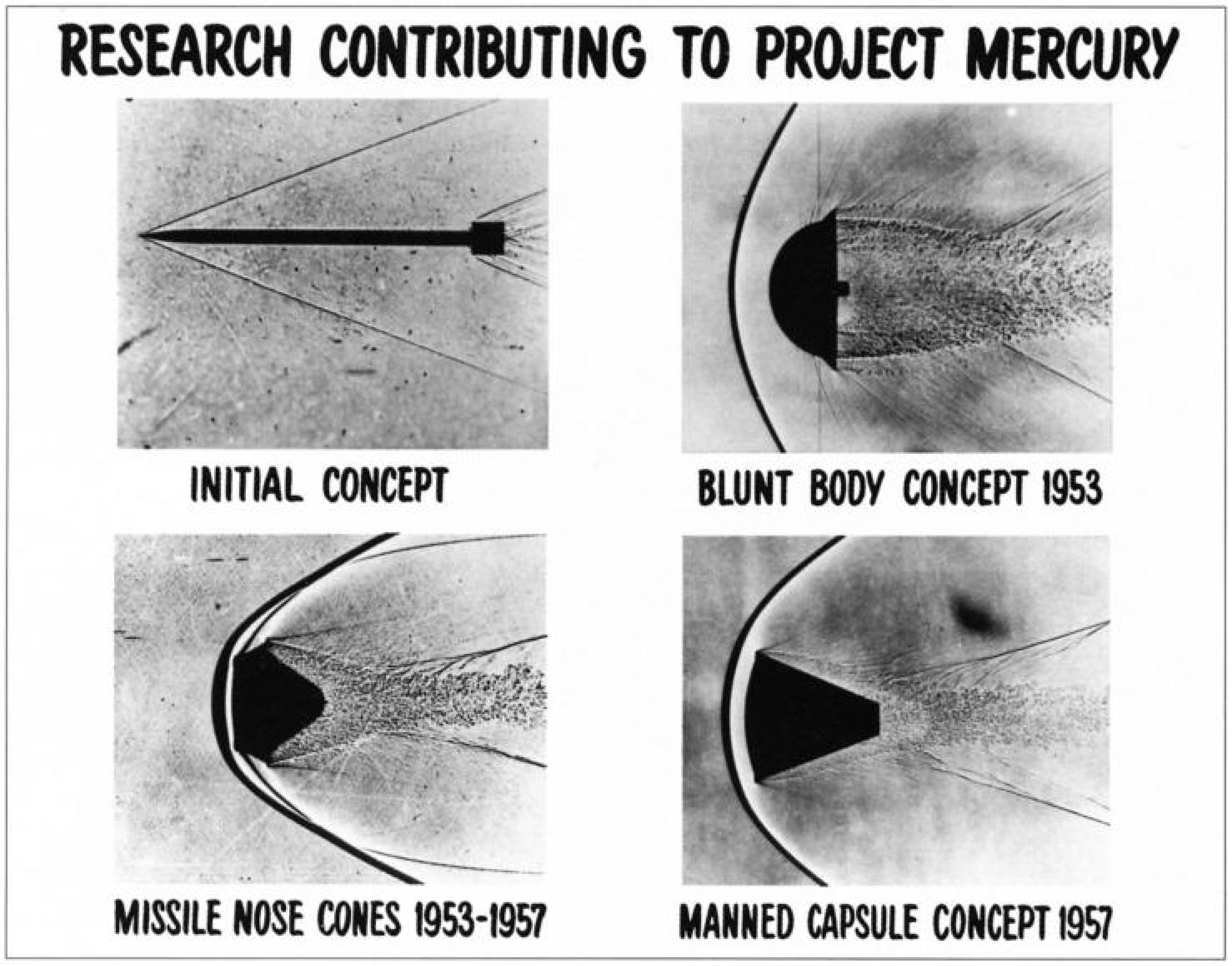
NASA's Lenticular Spacecraft

In 1959 NASA began to consider their major objectives for the coming decade. These stretched from Project Mercury, which would put the first American into space, to a Moon landing by 1970. The lunar mission was given a high priority within the agency and an initial proposal was put to the US Senate Subcommittee on Aeronautical and Space Sciences on 10th March 1960. NASA then requested approval of (up to) $15 billion over the next five years for this project. But man had yet to fly in space and there was little political enthusiasm for a risky multi-billion dollar Moon mission. As a consequence, the scheme was shelved, although NASA continued to develop it and soon gave it a specific name.

Abe Silverstein had already been responsible for naming the Mercury project and came up with Apollo for NASA's anticipated Moon mission. This proved to be a very popular choice. NASA's Space Task Group (STG) was now studying a number of three-crew spacecraft designs for the Apollo project and a small spaceplane soon won favour with the team. The other manned projects like Mercury and Gemini would use ballistic capsules that evolved from strategic missile warhead designs, but Apollo was anticipated to be a significant step forward in terms of engineering and functionality.

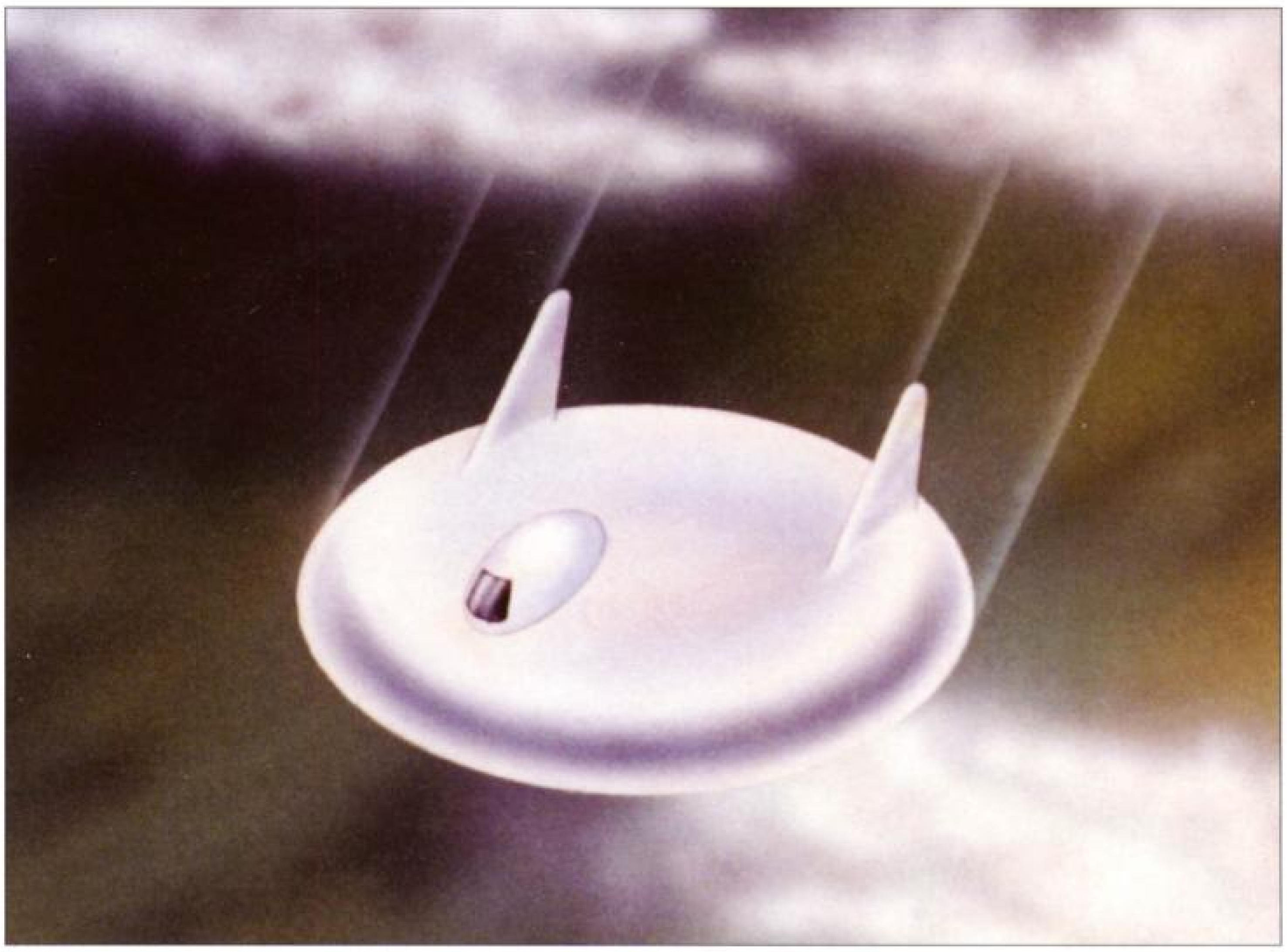
Within the STG it was believed that a small spaceplane offered better handling characteristics during re-entry and would allow horizontal landings on a dry lake bed or a proper runway. Furthermore, it might be possible to re-use the vehicle in the same way as the hypersonic North American X-15 rocketplane. Although a ballistic capsule was under consideration, three spaceplane configurations were given preference. These were the Ames M2-F1, M1-L half-cone and the Langley Lenticular Body, which was shaped like a classic flying saucer. During re-entry into the Earth's atmosphere each lifting body design would use the entire underside of the vehicle for braking. It was Alan B Kehlet of the STG who had first proposed a lenticular spacecraft, in 1959, and he suggested the use of deployable wings during the final landing approach. In fact Kehlet, and his colleagues Alan B Hasson and William W Petynia, were so convinced that a saucer was the perfect shape for a re-entry vehicle that they filed a patent on behalf of NASA.

Several major aerospace contractors were involved in these early Apollo studies and on 12th January 1961, NASA held the first series of technical meetings at the Ames Research Center to discuss progress on various topics

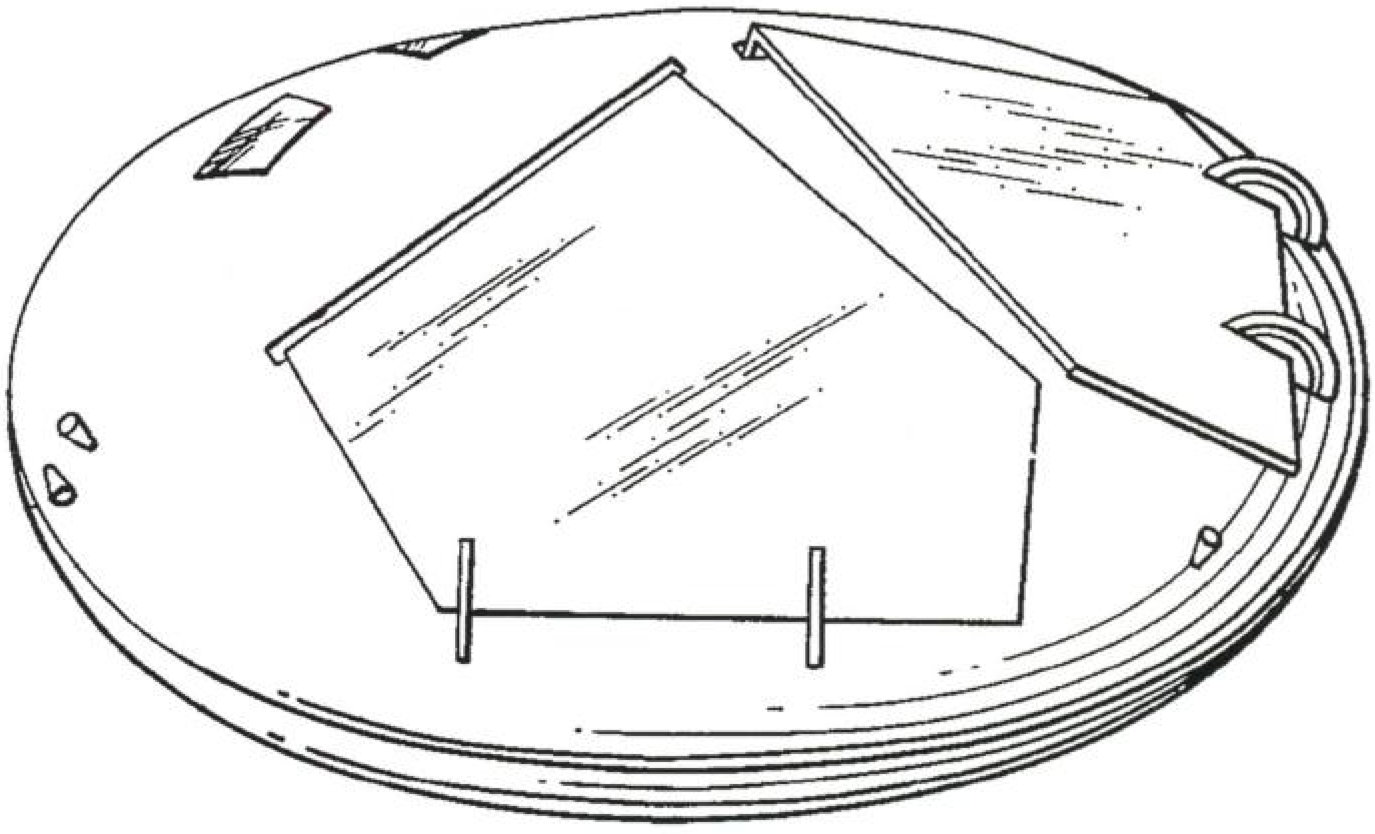

RESEARCH CONTRIBUTING TO PROJECT MERCURY
INITIAL CONCEPT
BLUNT BODY CONCEPT 1953
MISSILE NOSE CONES 1953-1957
MANNED CAPSULE CONCEPT 1957

Early studies for re-entry vehicles, which led to the Project Mercury capsule design. During the early phase of the Apollo Moon project, NASA scientists gave preference to the lenticular shape, but this was finally abandoned and a more advanced type of ballistic capsule chosen for reasons of simplicity. NASA that included the lifting body designs. General Electric, Bell Aerospace, Martin, Hydrag and Convair were studying all of the NASA concepts, from the baseline M-1 ballistic capsule to the lifting body proposals and including the lenticular craft which was favoured by the STG. Convair and their subcontractor Avco produced a refined version of the Langley lenticular design, which at 4.4 had the greatest hypersonic lift/drag ratio of all the re-entry vehicle proposals.

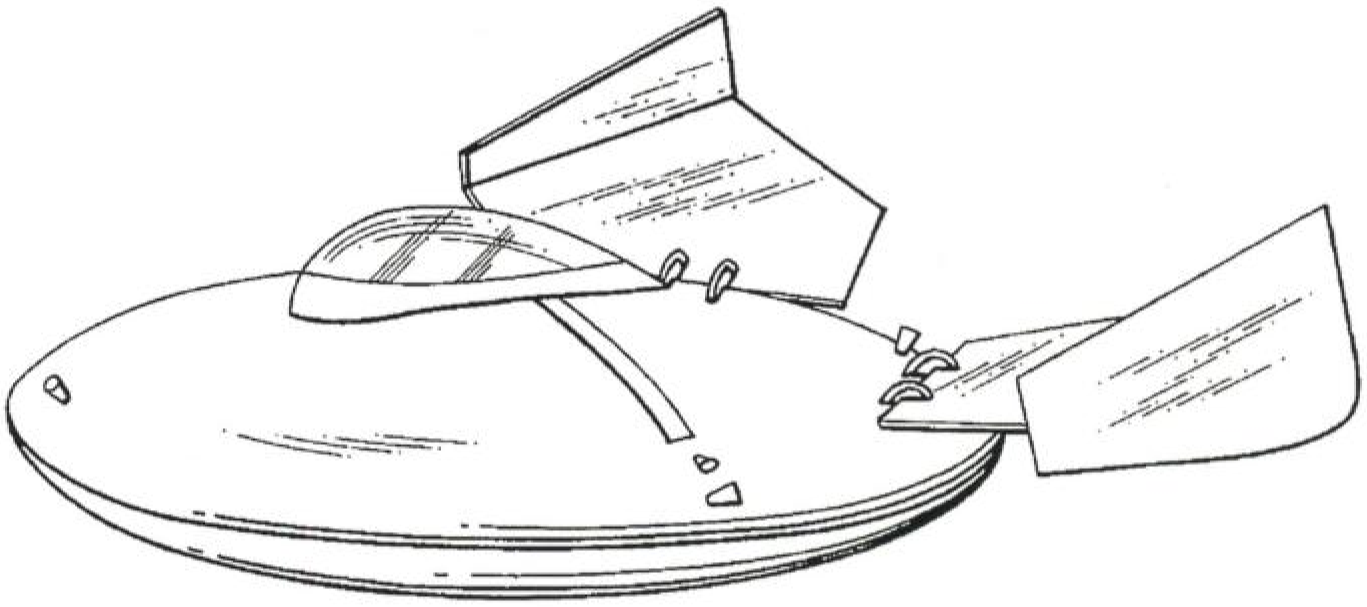
Their design would suffer from less severe afterbody heating than a cone or winged lifting body shape and, consequently, it would need less thermal protection and shielding. The vehicle had a gross weight of 5,218 lb (2,367kg) and a diameter of 16ft (4.88m). It also met the cross range requirement of 1,000 miles (1,600km). Because of its dimensions this spacecraft would have been packaged upside down on the top on the launch vehicle, with the propulsion module above it and



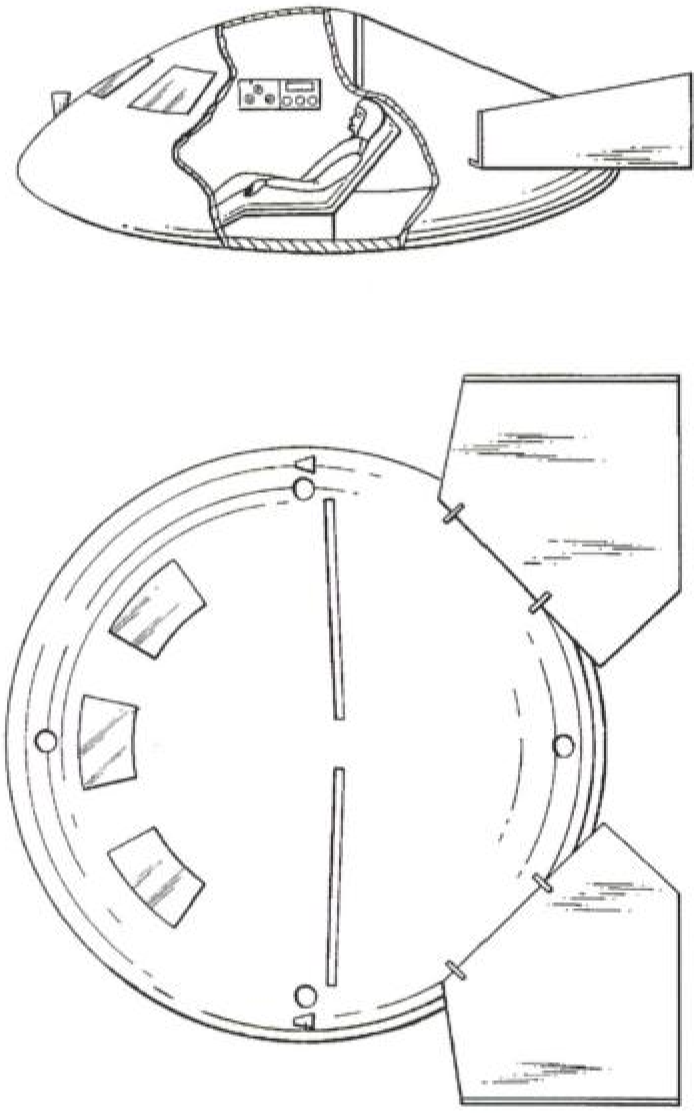
Above right: **Early artwork from NASA Langley, showing ideas for a flying saucer-shaped re-entry vehicle.** NASA



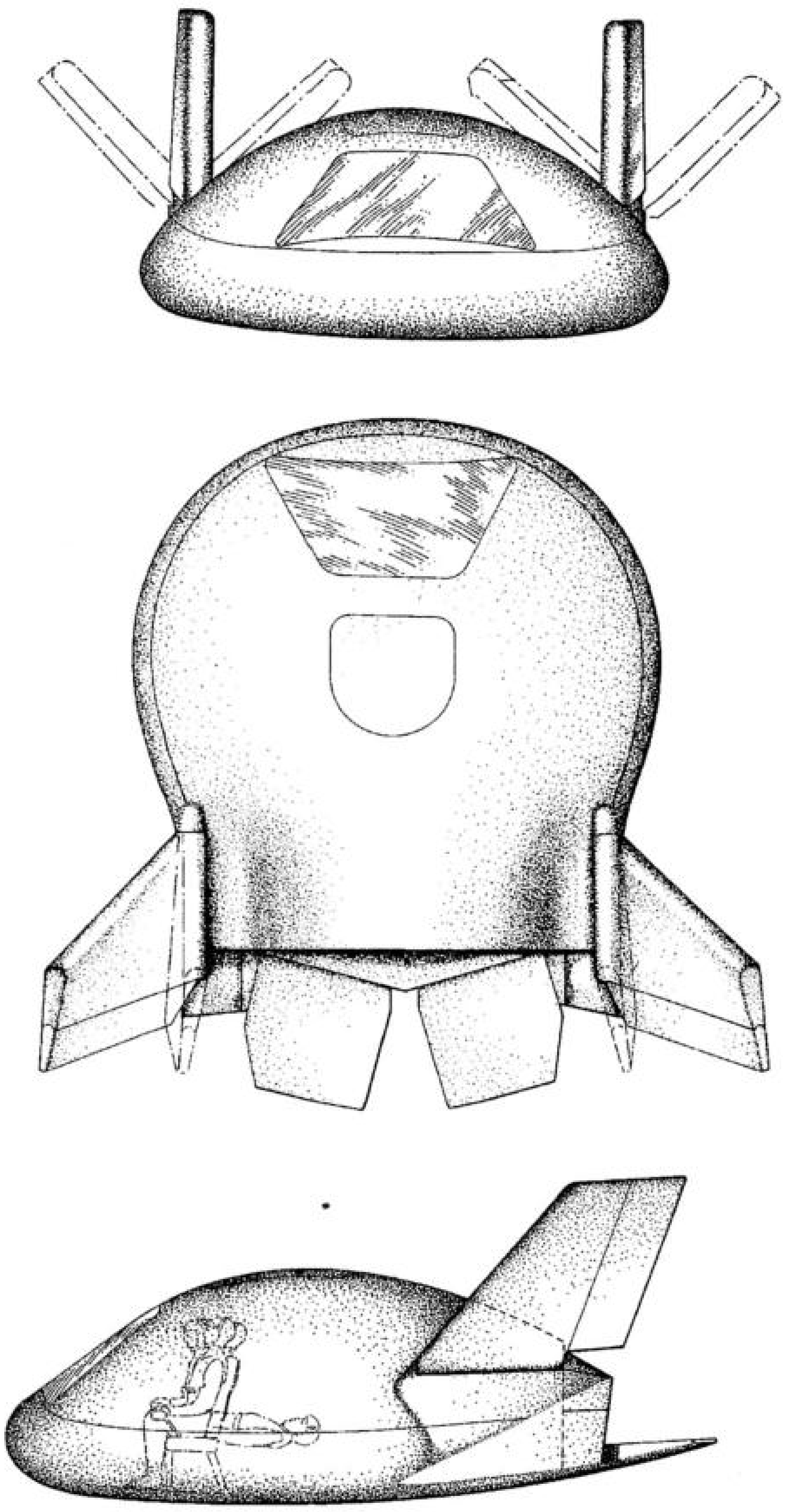
Right: **A drawing of the NASA Kehlet re-entry vehicle showing the wings fully folded.** US Patent Office

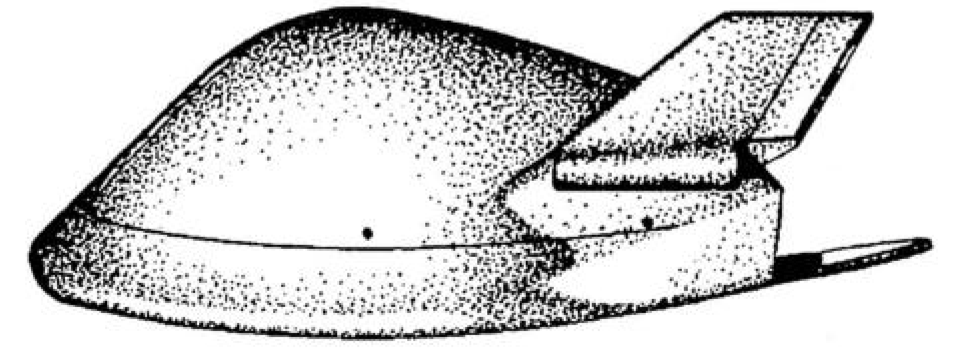


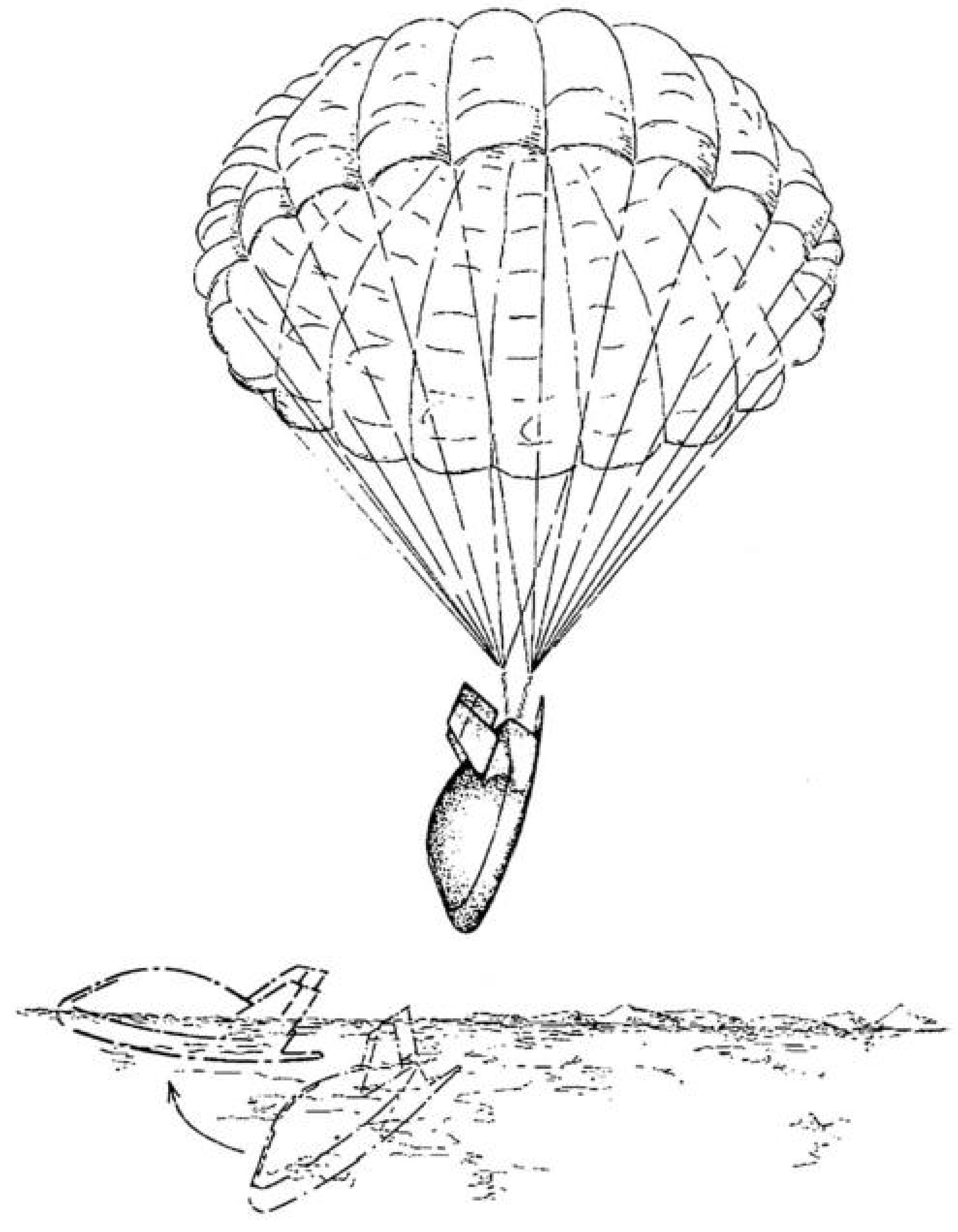
Below right: **The NASA Kehlet re-entry vehicle with wings fully extended.** US Patent Office



Below: **A circular re-entry vehicle conceived by NASA scientist Alan B Kehlet during the early part of the Apollo Moon program.** US Patent Office







Above left: **Bell Aviation, semi-saucer-shaped re-entry space vehicle designed by Bell Aviation for the Apollo Moon programme. The wings are folded until needed.** Bell Aviation

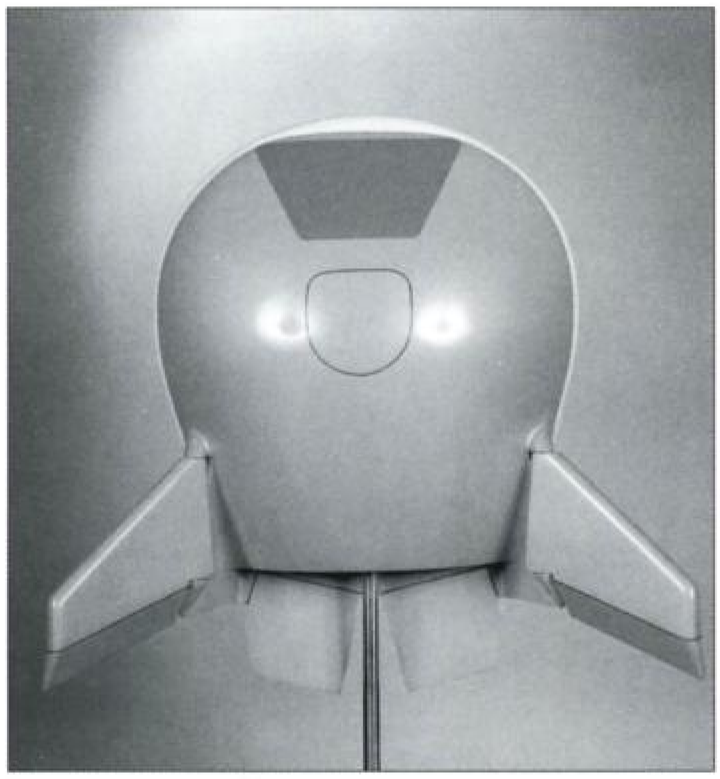
Top right: **Side view of the Bell Aviation, semi-saucer-shaped re-entry vehicle, designed for the Apollo Moon programme.** Bell Aviation

Lower right: **Bell semi-saucer-shaped re-entry vehicle makes a parachute landing in the sea.** Bell Aviation

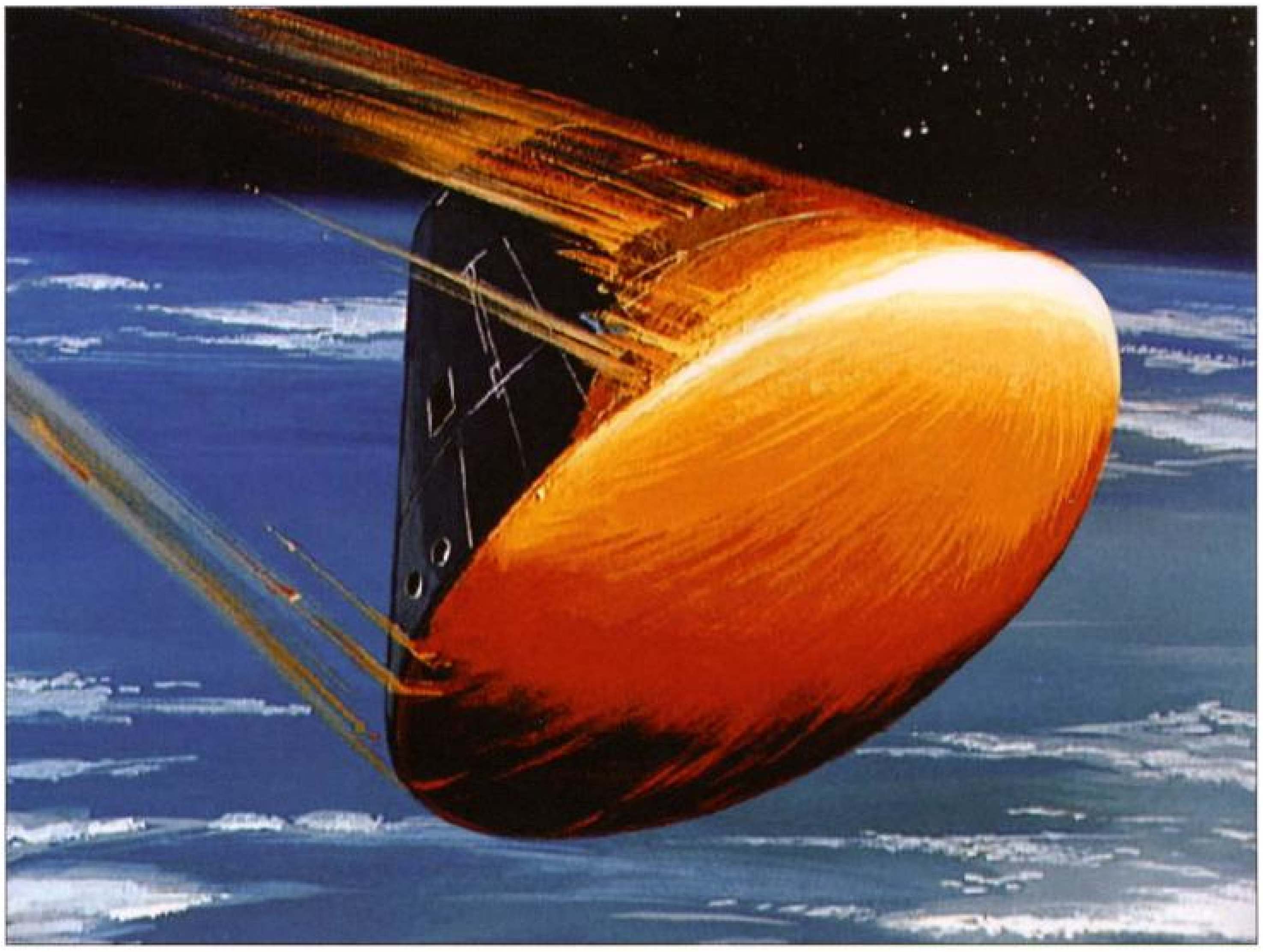
the mission module below. Crew seats that swivelled through 90° were proposed to fulfil the launch and landing requirements, with access via a hatch in the bottom of the saucer.

Aerodynamic control surfaces would be folded almost flat and only extended to improve handling during the final glide phase. Nevertheless, this design was considered very stable in terms of pitch and yaw, which made an emergency descent possible without the control surfaces in position. Several landing options were considered that included a conventional runway touchdown and parachute descent into water. But Convair engineers knew from the outset that this lenticular design would require different propulsion and mission modules from the STG's M-1 baseline specification. Providing an emergency launch escape system would also represent a serious technical challenge. By late March 1961 they had completed most of the technical work on the Apollo feasibility study contract and advised NASA that the basic lenticular design presented too many problems to proceed with. Convair completed this study with the recommendation that NASA should concentrate on developing the basic M-1.

Another favoured option for a semi-disc-shaped spacecraft was a design with a straight trailing edge, which was extensively researched by General Electric and Bell Aerospace. The concept had a lift/drag ratio of 0.70 and managed to avoid some of the heating and weight problems associated with the original Langley proposal. This Apollo design had a specified gross weight of 6,470 lb (2,936kg), a length of 15ft (4.57m), and a width of 10ft 10in (3.29m). It also met the specified cross range requirement. The spacecraft would sit above the mission module on the launch vehicle with access provided by a lengthy connecting tunnel. Radiative heat shielding was considered adequate for re-entry, but this would be supplemented with an additional ablative coating on the underside and short



Above: **Model built at NASA Langley during 1961 for the proposed Apollo spaceplane.** NASA



Right: **NASA artwork showing re-entry for Apollo 8. This design of space capsule was finally selected for the programme as the least demanding to develop.** NASA

folding control surfaces would be used during the glide phase.

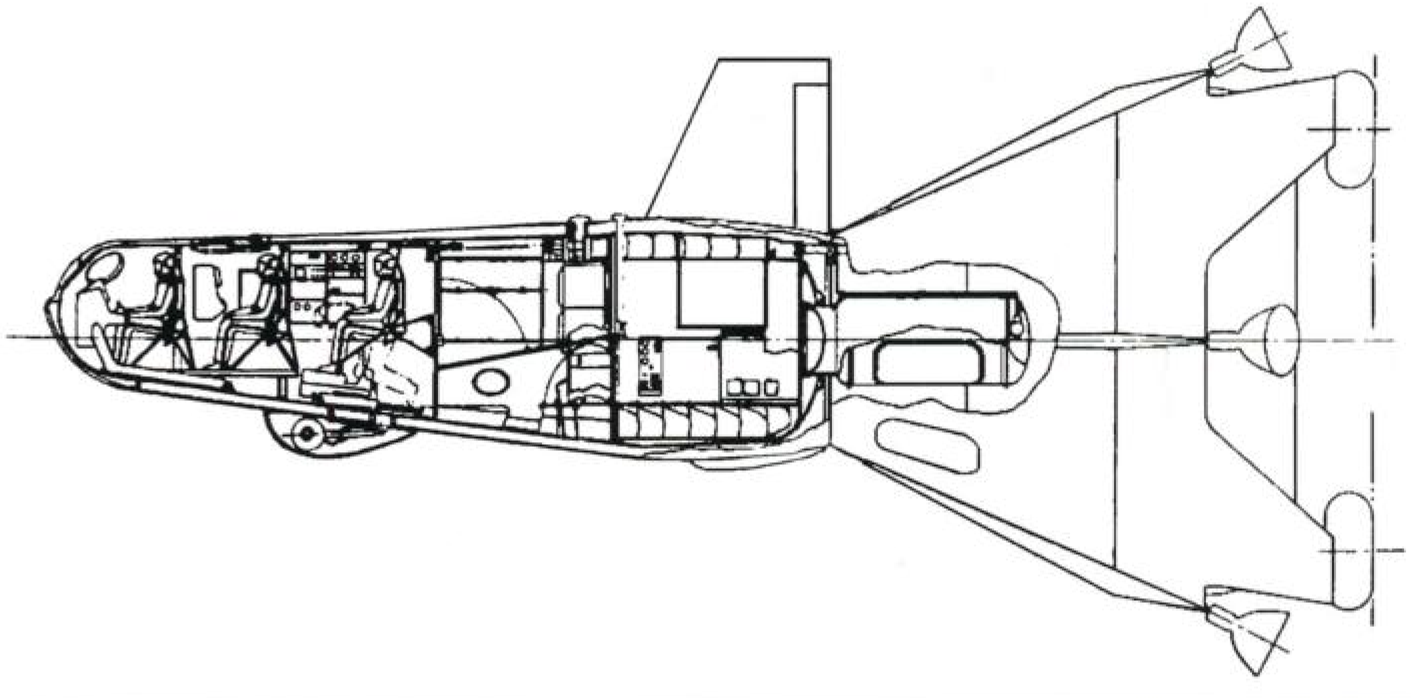
Bell Aerospace were very enthusiastic about this concept and proposed a number of landing options. These included a parachute descent into water and conventional runway touchdowns with skids or an undercarriage. However, General Electric realised that further development of this design would be accompanied by a string of complex engineering problems and it seems that Bell Aerospace finally concurred with their view. The STG then decided to proceed with the much simpler M-1 ballistic capsule and NASA were to eventually award North American Aviation a contract to build the Apollo command module.

Surprisingly, a very similar capsule design has been selected for NASA's Crew Exploration Vehicle (CEV), which will replace the Shuttle Orbiter. This module will form the central component of a new system, capable of ferry flights to the International Space Station (ISS), a return to the Moon and perhaps a trip to Mars or an asteroid rendezvous mission. Somewhat larger than Apollo, the four- to six-man CEV was selected on the grounds of safety and cost over the alternative lifting body designs. Of the three original lifting body designs produced in the early 1960s, only the M2-F1 was actually constructed and tested.

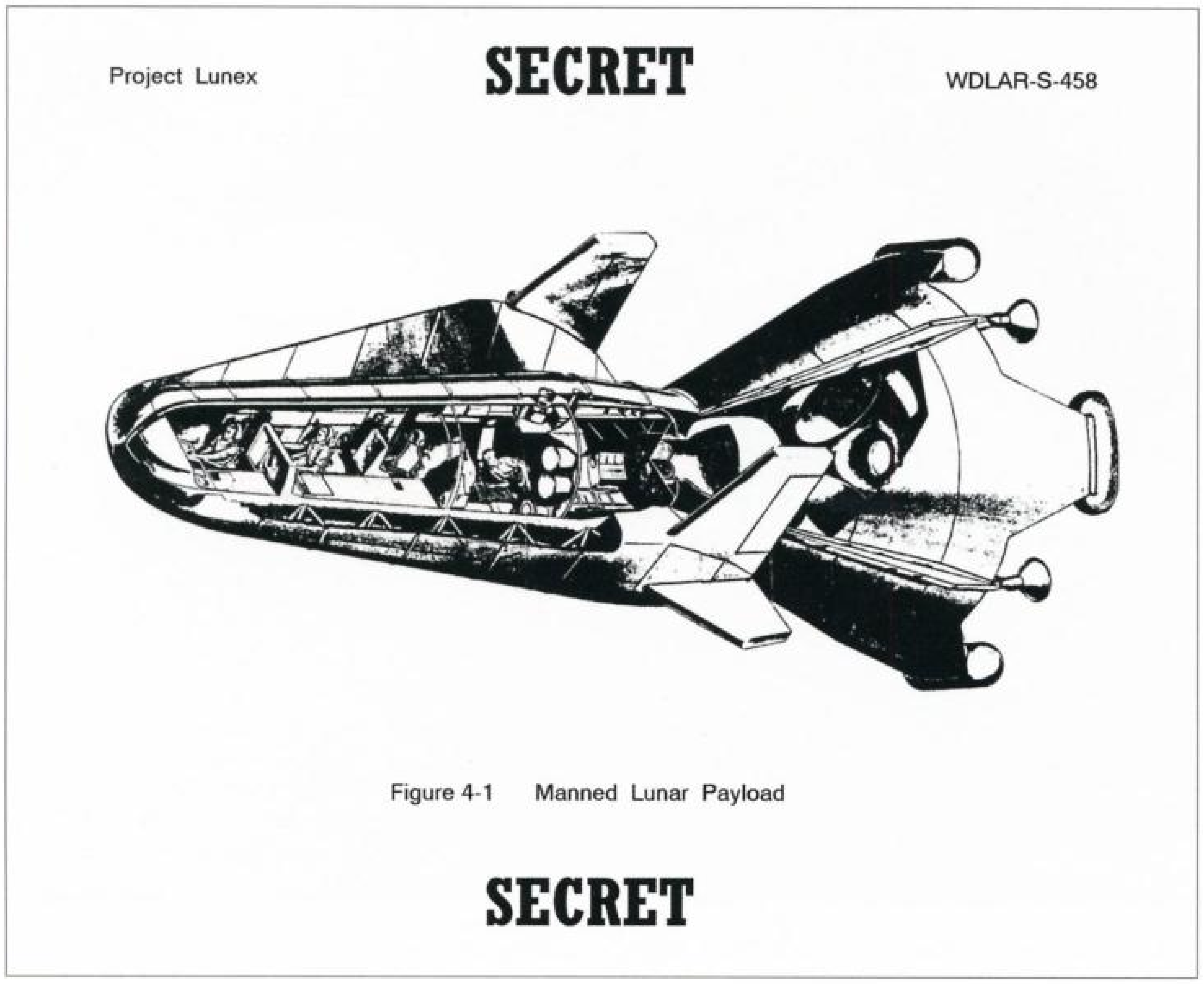
NASA was not the only agency to have an interest in this research work and, some time before America's Moon mission had been approved by the Kennedy Administration, much of the initial Apollo R&D was moving sideways into the military black projects domain. The USAF had been working on its own top secret plan to establish a base on the Moon by 1967 and studies for this project were codenamed SR-183 and later SR-192, which had the title: 'Military Bombardment Retaliatory Capability From a Moon Base'. This description pretty much summed up the entire scheme! The overall project was given the name Project Lunex (Lunar Expedition Program) and Major General J R Holzapple took charge of the planning.

Central to Project Lunex was a new space transportation system, which included a very sophisticated re-usable lifting body vehicle that was launched into space by a massive three-stage booster rocket. This delta-shaped spacecraft would be 52ft (15.85m) in length and was attached to a special tail unit that allowed it to land on the Moon. Once their mission had been completed, the crew would blast off from the lunar surface leaving the tail unit behind and return to Earth, making a conventional runway landing at a location such as Edwards AFB. The Lunex spaceplane was designed with features that were well ahead of its time, and in some cases remain beyond present-day realisation.

Simply on the basis of this open-ended approach to development, there was never any likelihood that the USAF would obtain funding for their highly classified multi-billion dollar project. Project Lunex met with cancellation during early 1961 and in keeping



Cross-section of the USAF's proposal for the Project Lunex lifting body spacecraft, fitted with lunar landing unit. USAF



Project Lunex

SECRET

WDLAR-S-458

Figure 4-1 Manned Lunar Payload

SECRET

The USAF Project Lunex spacecraft designed to make a Moon landing and return to Earth. This early 1960s concept remained secret for several decades. USAF

with a broadly similar US Army proposal known as Project Horizon, it would remain secret for the remainder of the 20th century. However, the military retained an interest in the Apollo Project and there were plans to build a version of the lunar module as an orbital combat vehicle, which would be capable of destroying Soviet satellites. Meanwhile, the USAF was using NASA's lenticular vehicle studies for the design of a new top-secret strategic weapons system.

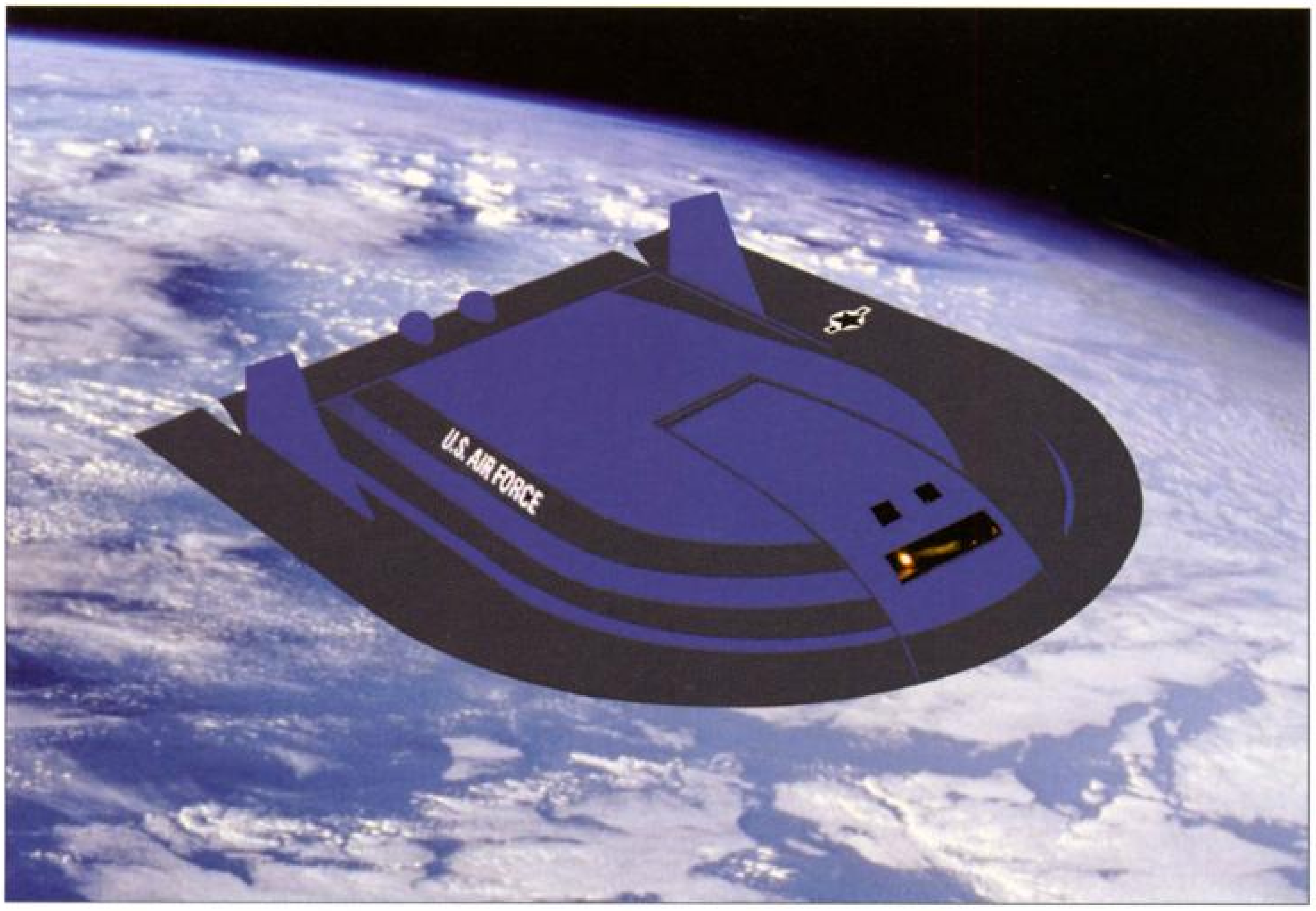
Orbital Flying Saucers

Drawing on research conducted by NASA into lenticular-shaped re-entry vehicles for the Apollo Project, the USAF decided to initiate a semi-disc-shaped orbital bomber project. Their chosen contractor was North American Aviation's Los Angeles Division, who received a commission to develop this spacecraft at the beginning of the 1960s. Known as the Lenticular Re-Entry Vehicle (LRV), this proposal was funded by the USAF's Air Research & Development Command at Wright-Patterson AFB, Dayton, Ohio.

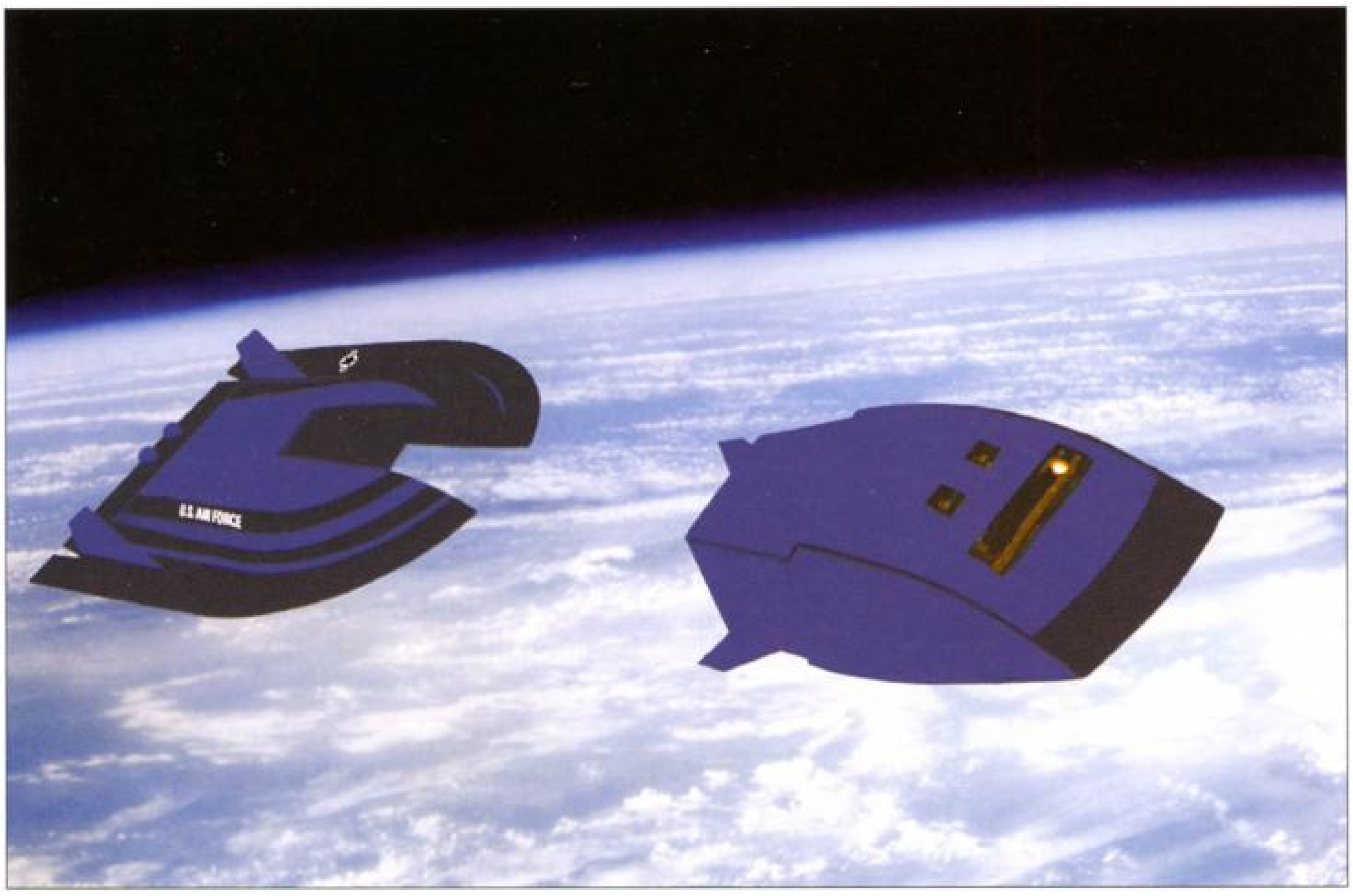
Running in parallel to the Boeing X-20 spaceplane, North American's alternative project used technologies that promised a full orbital capability, longer endurance and a significant offensive potential. Designed to undertake a six-week orbital mission during times of crisis, the LRV would accommodate a crew of four. From 345 miles (555km) above the Earth the LRV would be able to deploy four winged thermonuclear-tipped missiles that could be parked in orbit or directed towards ground targets. These weapons would be stored at the back of the craft and ejected rearwards.

The specification of the space-to-ground missile is unknown, but it has been suggested that each would be equipped with Multiple Independent Re-entry Vehicle (MIRV) warheads capable of inflicting massive damage on a range of pre-selected targets. The dimensions of the LRV are quoted as being 40ft (12.2m) in diameter with a central thickness of 90in (228.6cm), tapering to 6in (152.4cm) at the edge. Launch weight was set at a modest 45,000 lb (20,411kg) and the landing weight with unused missiles would be 33,395 lb (15,147kg); in a post-combat situation the empty LRV's weight would be reduced to just over 17,000 lb (7,711kg). The launch method for this vehicle is understood to have been a two-stage fully re-usable booster system using a pair of winged vehicles, which would have been sled-launched along a giant monorail track. Key areas of the LRV would be strengthened to withstand high 8G acceleration on lift-off and problems associated with wind shear. Details of the launch system have never been released, but they are thought to be very similar to those found in a later study undertaken for NASA, which was based on the LRV.

Launching a manned spacecraft from a monorail was initially proposed by the Austrian scientist Dr Eugen Sänger (1905-1961), who designed the first technically realistic spaceplane. During World War Two Sänger was asked to develop his spaceplane concept into a vehicle capable of reaching America and this project became known as the Sänger Stratospheric (or Amerika) Bomber.



Concept art for the Lenticular Re-Entry Vehicle (LRV) – North American Space Bomber. Bill Rose



Following a serious emergency, the crew of the North American Space Bomber use the escape capsule to return to Earth. Bill Rose

Assisted by the mathematician Dr Irene Bredt (one of his students who eventually became his wife), Sänger produced plans for a very sophisticated single-seat vehicle with an overall length of 91ft (27.74m) and an estimated empty weight of 22,000 lb (9,979kg).

The idea was to launch the spaceplane from a 2-mile (3.2km)-long monorail using a very powerful booster stage. This massive rocket would burn for eleven seconds and the spacecraft would leave the monorail an angle of 30°. After reaching a height of about 1 mile (1.6km) and a speed approaching Mach 1.5, the spaceplane's main engine would ignite and burn for a further eight minutes until a velocity of nearly 14,000mph (22,530kph) was achieved at an altitude in excess of 100 miles (160km). The vehicle would then progressively bounce down through the atmosphere and it was hoped this would prevent the airframe from overheating. After delivering its single bomb (believed to be a dirty radiological weapon) to a US city, Sänger's spacecraft would glide to a safe landing site. It was thought that only two or three missions would be required to bring the Americans to the bargaining table.

Sänger and Bredt continued to develop this concept. Some experimental engines were given trials and the construction of a full-size mock-up was undertaken at the Lofer research facility near Salzburg. However, it became obvious that relatively little was known about the behaviour of metals and other materials at ultra-high temperatures and the spaceplane project was abandoned.

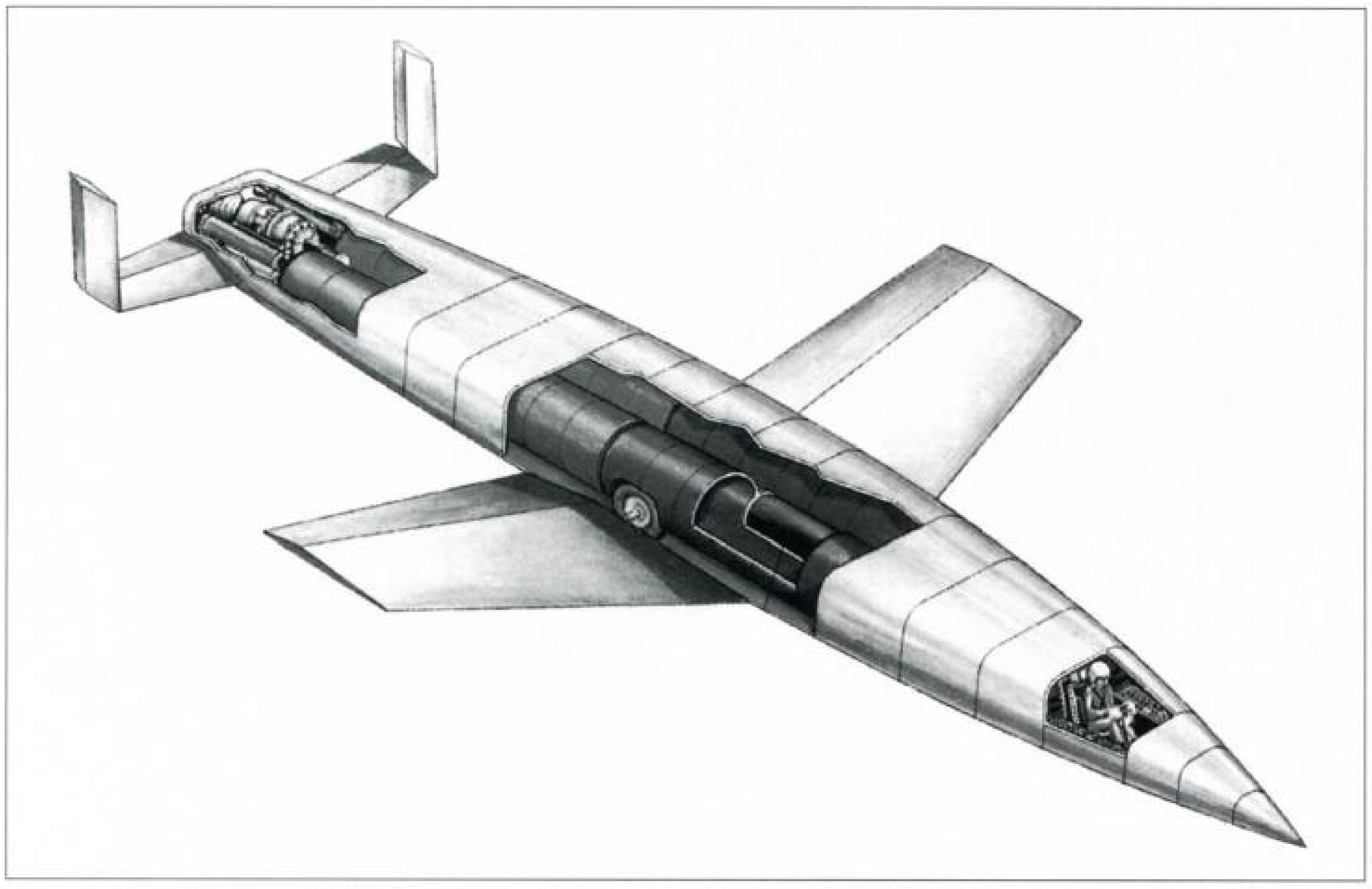
Much of the work undertaken by the Sängers found its way into later US and Soviet manned spacecraft projects and the LRV can be seen as a direct descendant of the Sänger's wartime research. Like the Shuttle Orbiter, the LRV would have been equipped with its own rocket propulsion system burning liquid fuel, although there have been suggestions that a nuclear NERVA option was under consideration. Power for the vehicle's electrical systems was to be provided by a small 7kW nuclear reactor and the central section of the LRV was built as an escape capsule for emergencies, using a separate 50,000 lb (222.2kN)-thrust solid fuel rocket. This escape capsule would double as the LRV's flightdeck and could be detached in the event of an unspecified emergency. The capsule would behave like a small lifting body while making its re-entry, with final descent and landing controlled by parachutes.

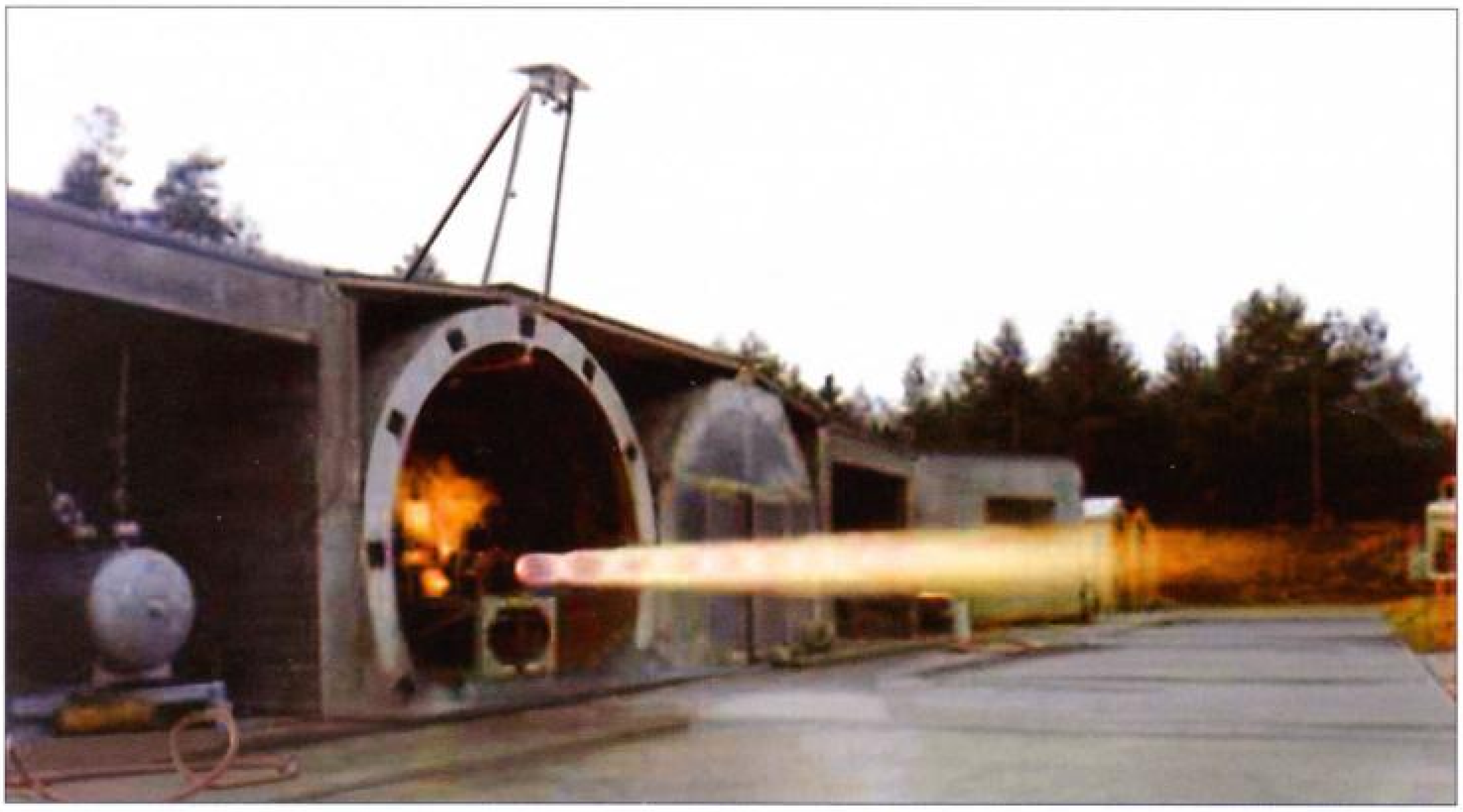
On completion of an orbital mission, the LRV would use its main propulsion system to leave orbit and would then enter the atmosphere edge-on, with much of the disc's external surface area being used to dissipate heat. When the re-entry phase was completed, the disc shape would act as a wing and the small tail fins and ailerons would provide directional control. Landing on an area of dry lakebed would be accomplished using small retractable skids. It is also possible that parachutes or an inflatable wing were considered as an additional means of controlling the LRV's descent and landing. Although this pro-

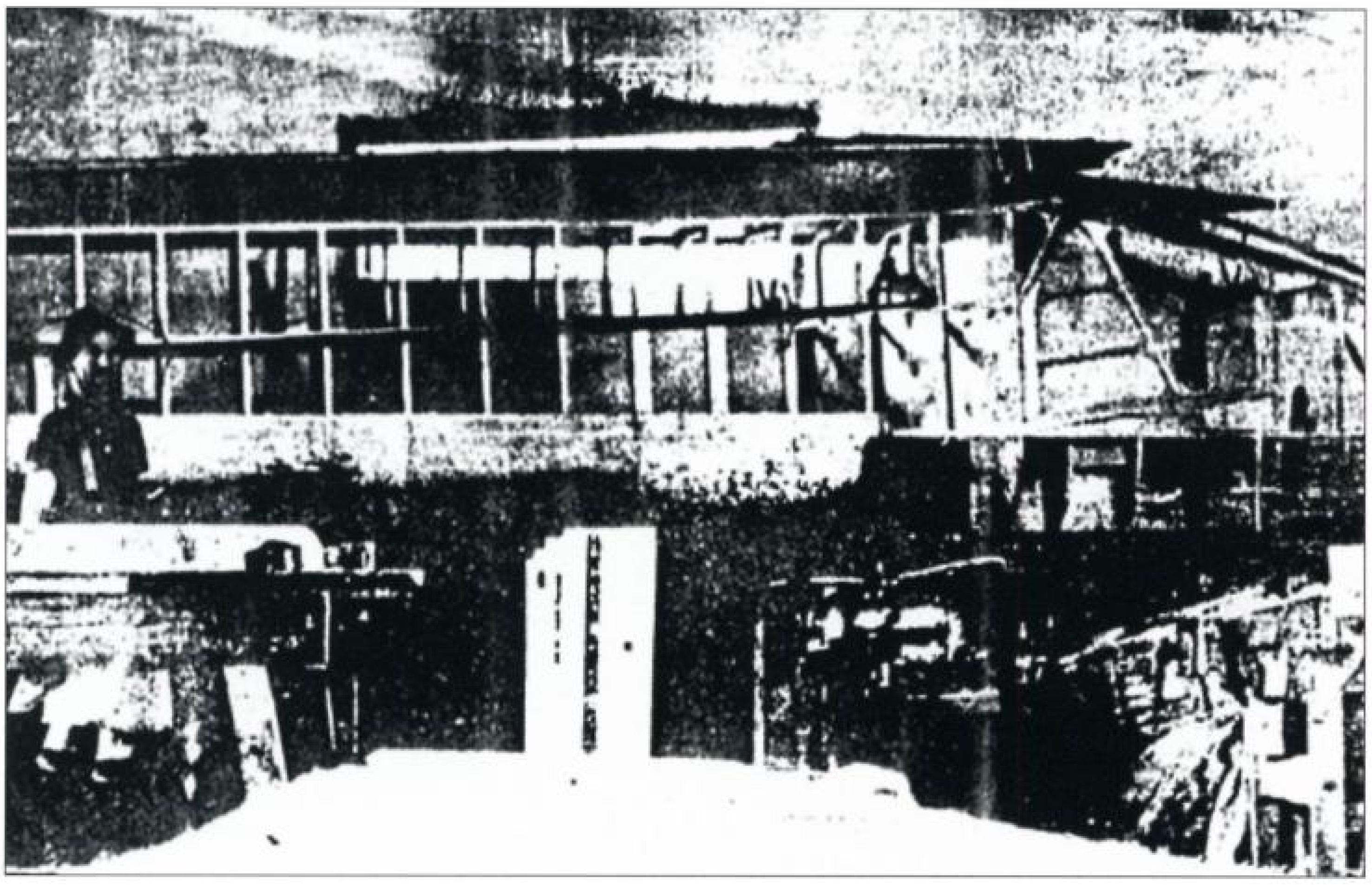
LRV Specifications

Role	Strategic Nuclear Strike/ Reconnaissance Spacecraft
User	USAF
Contractor	North American Aviation
Accommodation	Four
Typical mission duration	Six weeks
Dimensions	
Diameter	40ft (12.19m)
Centre	90in (228.6cm)
Edges	6in (15.2cm)
Wing Area	1,548ft^2 (144.0m^2)
Weights	
Launch	45,000 lb (20,412kg)
Landing	33,395 lb (15,148kg)
Empty	17,000 lb (7,711kg)
Engines	
Main	Liquid fuel rocket engines or NERVA nuclear propulsion
Capsule	Solid fuel 50,000 lb (222.2kN) thrust rocket motor
Electric power	7Kw Thermal Nuclear
Weapons	Four missiles with thermonuclear warheads
Launch vehicle	Sled-launched two-stage re-usable spaceplane system

The Austrian scientist Eugen Sänger, who is rightly credited with designing the first spaceplane. His work was very influential and can still be seen today. via Bill Rose







Sänger spaceplane designed during World War Two. This concept was decades ahead of its time and is now seen as the true ancestor to all vehicles like the US Shuttle Orbiter. via Bill Rose

Under test during World War Two, the liquid-fuel rocket engine designed for use with the Sänger spaceplane. via Bill Rose

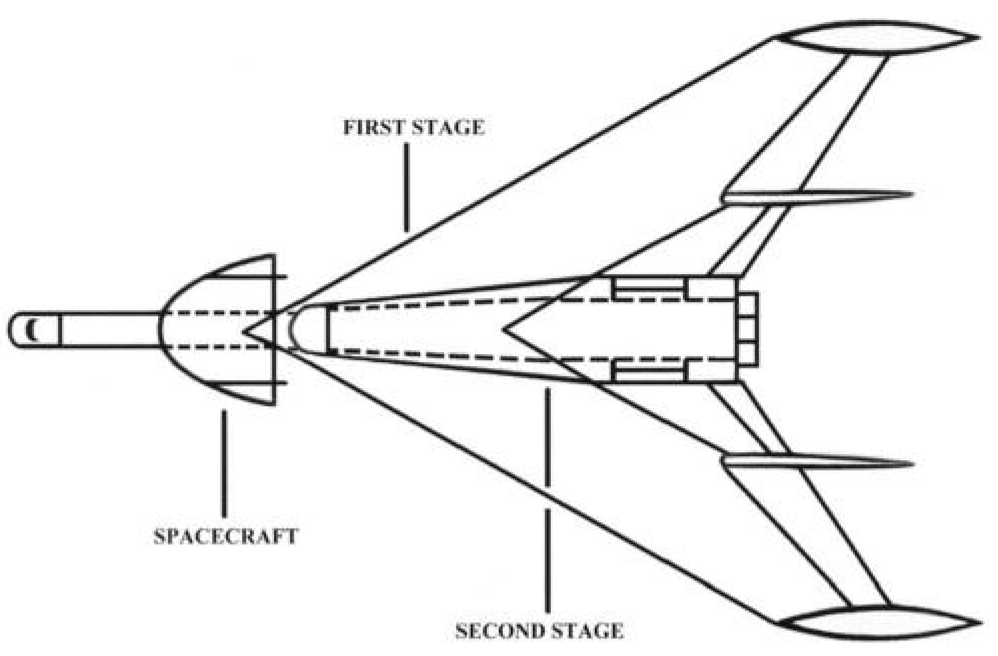
This US Army document is thought to show a mock-up of the Sänger Spaceplane built at the Lofer research facility near Salzburg and discovered by the US Army when the war ended. US Army

ject was unknown outside official circles, the USAF at Wright-Patterson AFB formally reclassified the LRV space bomber as Secret on 12th December 1962.

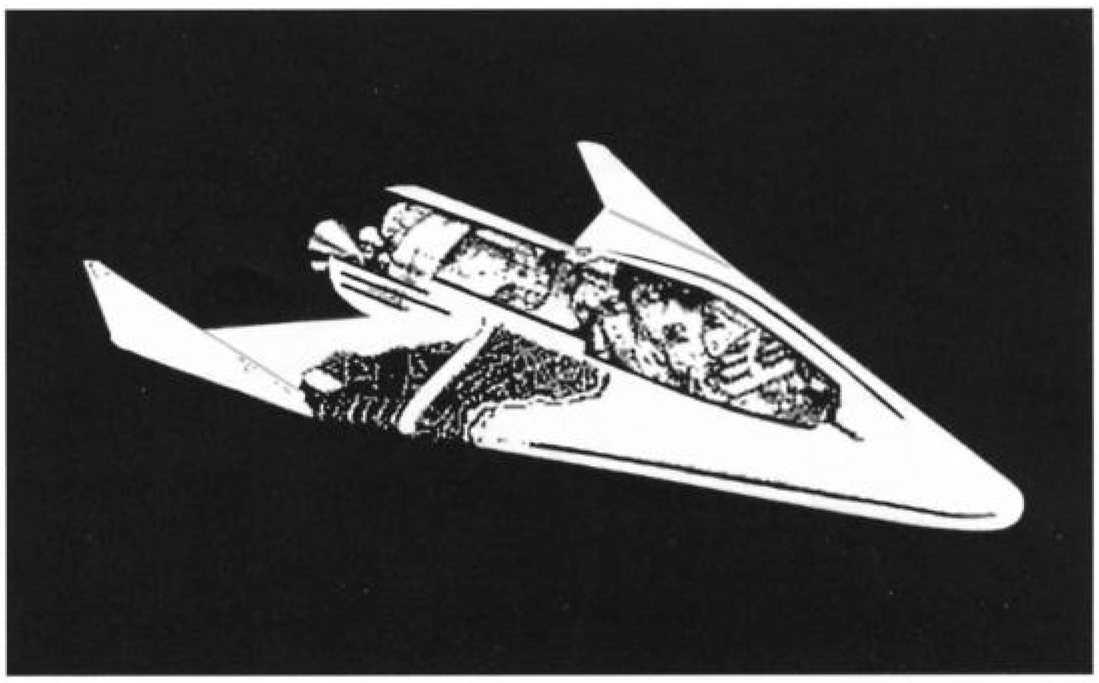
Studies may have continued beyond this point, probably involving wind tunnel tests and perhaps air-drops of scale models, but nothing else is known about the project. Speculation that the LRV was secretly built and tested appears totally unfounded, as it would have been almost impossible to hide the launch of an LRV on a high-altitude or orbital test flight. It is always possible that a rumoured full-sized mock-up was assembled, but no details of this have been released.

Many elements of the LRV resurfaced during 1963 after NASA's Marshall Space Flight Center awarded North American Aviation a $342,000 contract to study a spaceplane system called the Reusable Ten Ton Orbital Carrier Vehicle (RTTOCV). North American's system comprised a compact lenticular-shaped spacecraft, which was almost identical to the LRV in appearance. It would be capable of carrying ten crewmembers or ten tons of cargo to a future space station. The sled-launched booster system consisted of two fully reusable delta-winged vehicles. The larger vehicle would be 108ft (32.9m) in length and powered by one F-1 and two H-1 liquid fuel rocket motors, along with two turbojets for return to base and a controlled runway landing. The second smaller but similar stage would be powered by three liquid fuel J-2 engines used for the Saturn rocket. The gross lift-off weight for the entire system was projected at 605 tons (614,680kg) and the payload capability was expected to be marginally better than that specified by NASA, with the ability to carry twelve astronauts or twelve tons (10,886kg) of cargo to a 114-mile (185km)-high orbit, with an inclination of 28°.

Lockheed were awarded a broadly similar eighteen-month research contract by NASA to conduct a sled-launched manned spacecraft study under the same RTTOCV programme. The Lockheed study evolved from



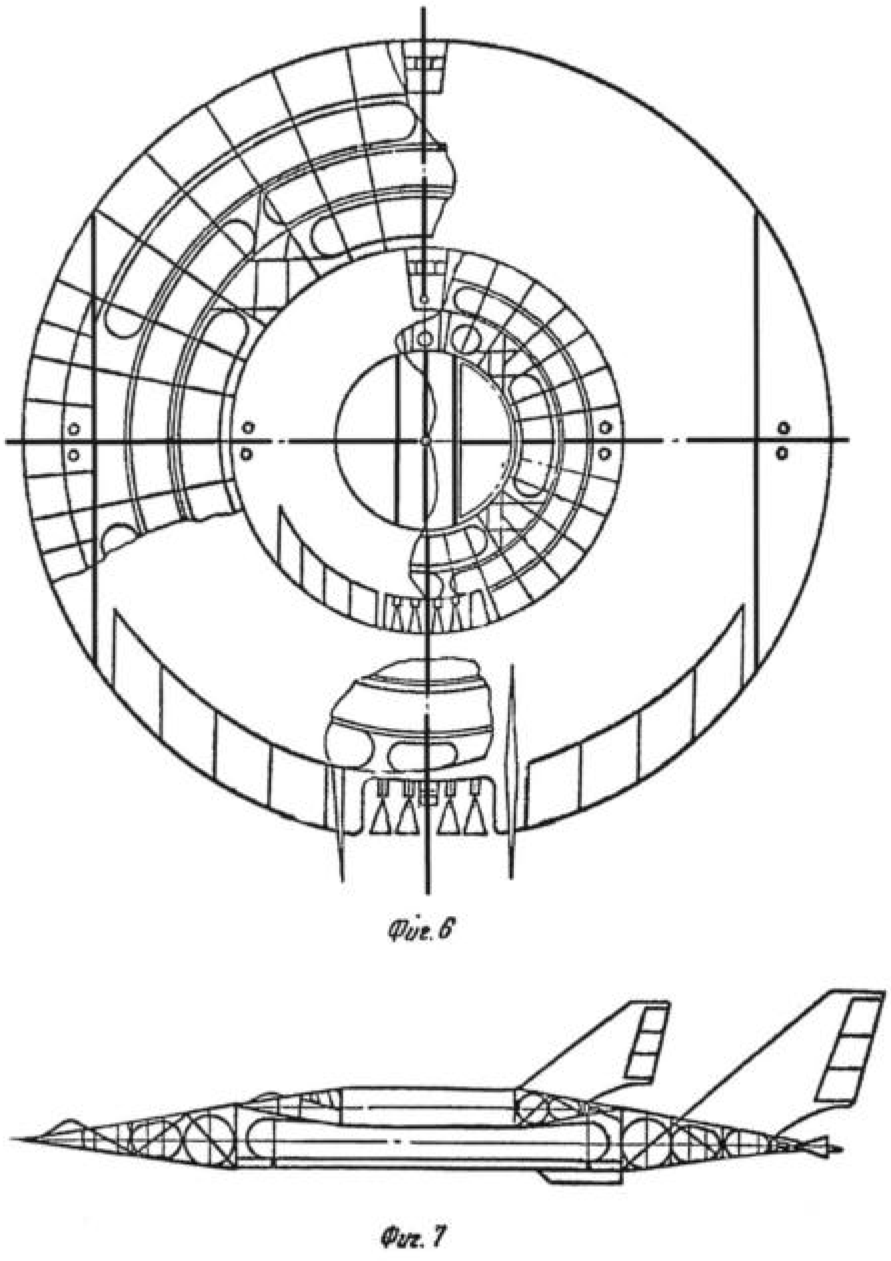
RTTOCV Two-stage re-usable launch vehicle developed for the NASA sled-launched spaceplane project. This system is thought to be identical to that proposed for the USAF's LRV. Bill Rose



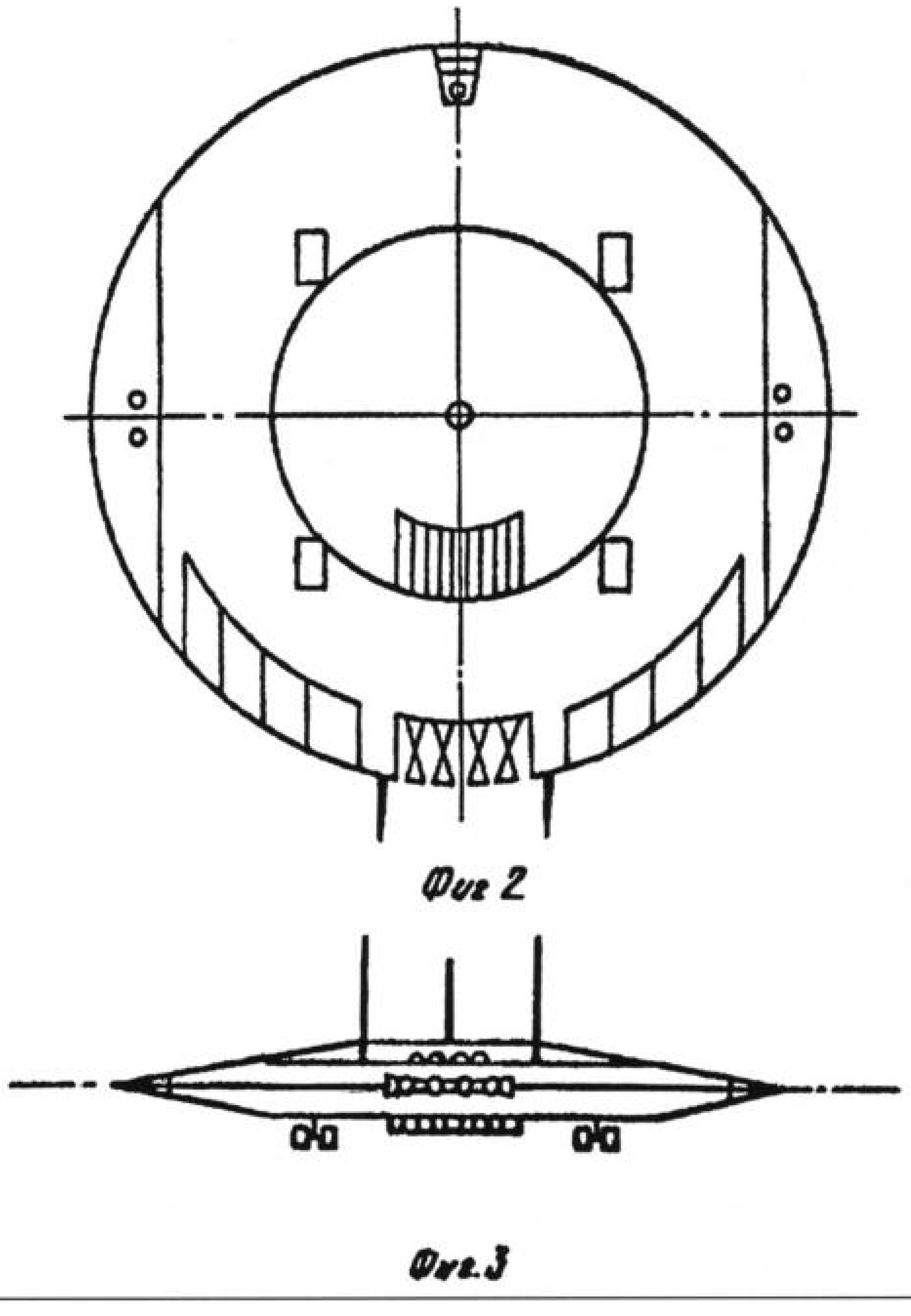
One of Lockheed's proposals for NASA's RTTOVC programme. NASA

an earlier project, which was conducted for the USAF in association with Hughes. Their final design took the form of a two-vehicle spaceplane system. The manned (or unmanned) booster was a winged canard powered by a liquid fuel rocket engine and supplemented by turbojets to facilitate the return to base and a controlled runway landing. The second stage spaceplane would be carried into orbit by LH_2 rocket propulsion and it would make an unpowered return to base. Gross weight for the complete system was estimated at 453 tons (460,248kg) and the spacecraft would be capable of lifting a payload of ten astronauts and 3.3 tons (3,353kg) of cargo into orbit.

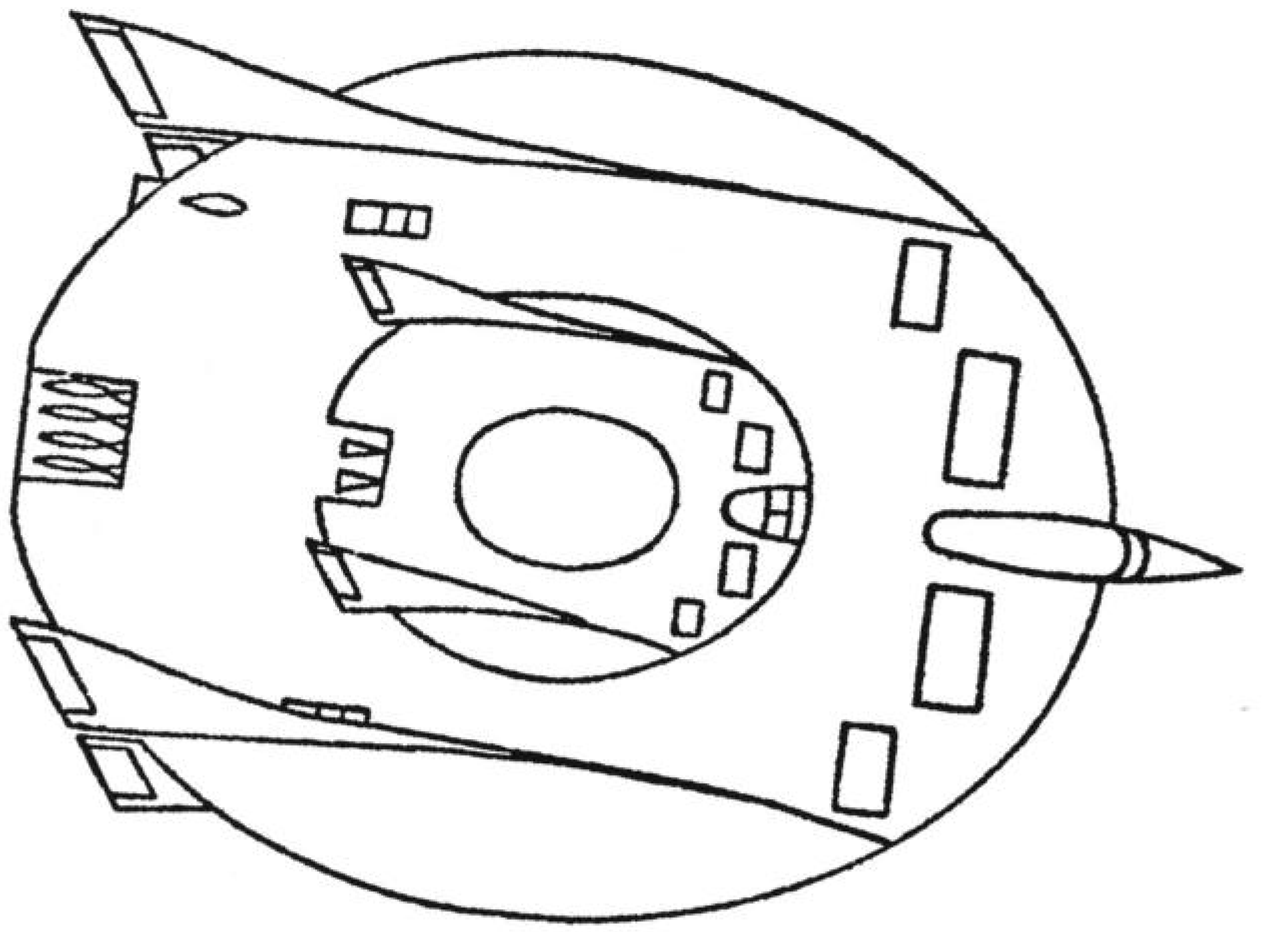
At 1964 rates the estimated cost of developing this system was $3 billion and Lockheed envisaged a 100-passenger-carrying version of the system being possible by the 1980s, using more advanced engines. NASA's RTTOCV programme never progressed beyond a concept, but some aspects are thought to have reappeared during 1982 when Boeing undertook a classified USAF sponsored study called Science Dawn. This project attempted to establish if it was possi-



Two-stage-to-orbit Sukhanov rocket powered flying disc configuration. via Bill Rose



Orbital vehicle design for Sukhanov two-stage-to-orbit flying disc proposal. via Bill Rose



Two-stage-to-orbit Sukhanov flying disc configuration with cockpit capsule used for primary vehicle. via Bill Rose

ble to build a sled-launched single-stage-to-orbit vehicle although, due to various technical considerations, research was finally terminated in 1986.

Sukhanov Spacecraft and Long-Range Flying Discs

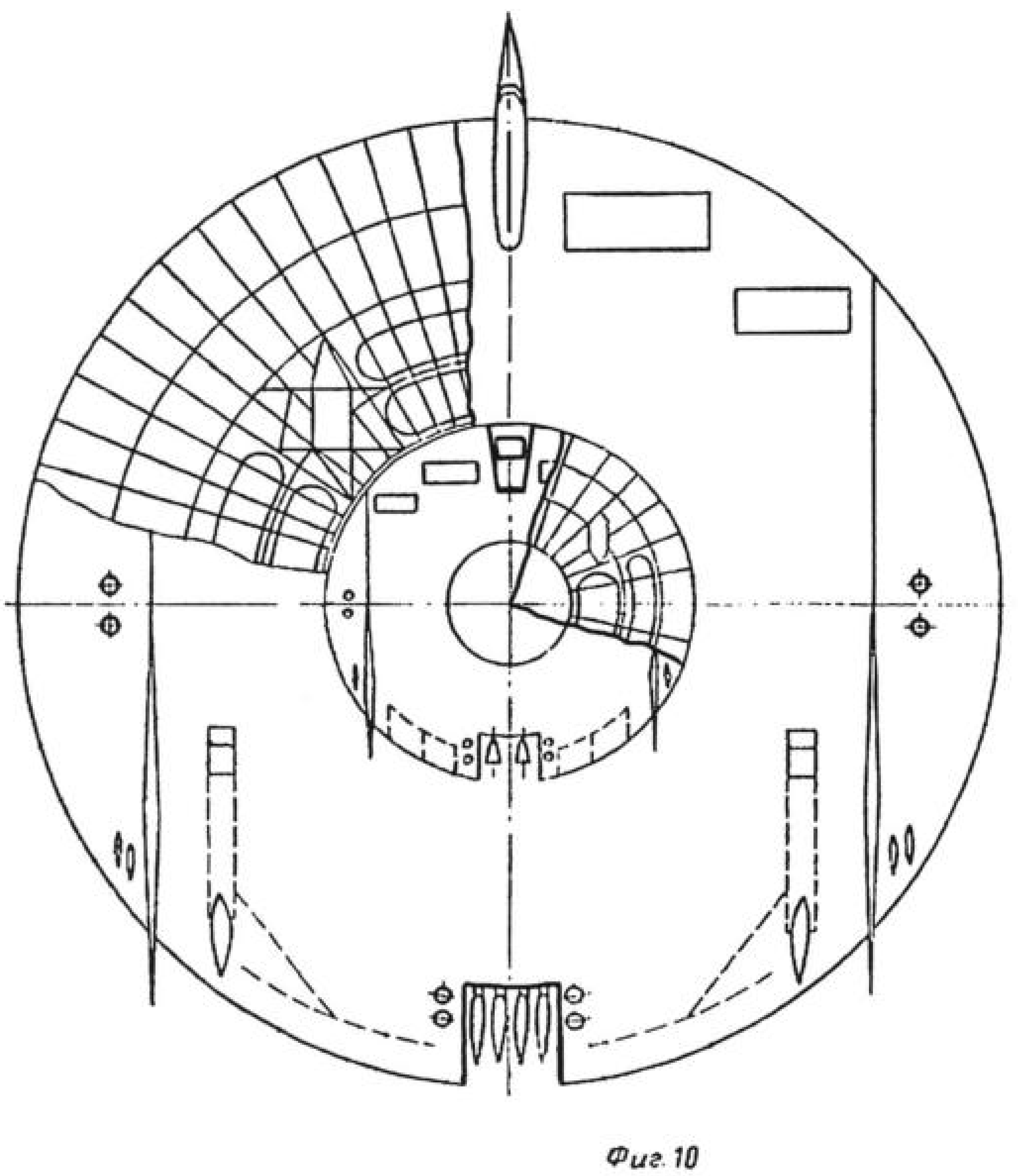
In the early 1960s the Soviet Union began work on a series of secret studies that broadly mirrored America's saucer-shaped orbital bomber. Sukhanov's team were primarily responsible for this project, acting as consultants for Ilyushin. While the Americans intended to launch their saucer-shaped spacecraft and the delta-winged X-20 Dyna Soar spaceplane by means of liquid-fuel booster rockets, the Russians recognised the vulnerability of such a system to pre-emptive attack and selected a fully re-usable runway-launched two-stage-to-orbit spaceplane. The disc-shaped mothership would lift off under the power of its four liquid-fuel rocket engines, carrying a smaller disc-shaped spacecraft that was approximately half its diameter.

Having reached Mach 5 and an altitude of about 175,000ft (53,000m), the spacecraft would be released from the mothership. It would then climb to Low Earth Orbit (LEO) under the power of four or five liquid-fuel rocket engines, having the ability to reach an altitude of 620 miles (1,000km). The mothership would return to base using auxiliary jet engines for a controlled runway landing while the spacecraft would make an unpowered glide back to base after completing its mission.

Several different disc-shaped designs were studied for the spacecraft, which all used a forward cabin area. Small reaction jets would provide manoeuvring capability in space and

Below left: **Two-stage-to-orbit Sukhanov flying disc configuration with cockpit capsule used for primary vehicle.** via Bill Rose

Below: **Sukhanov rocket-powered disc-shaped vehicle with single tailfin showing liquid fuel storage tanks.** via Bill Rose



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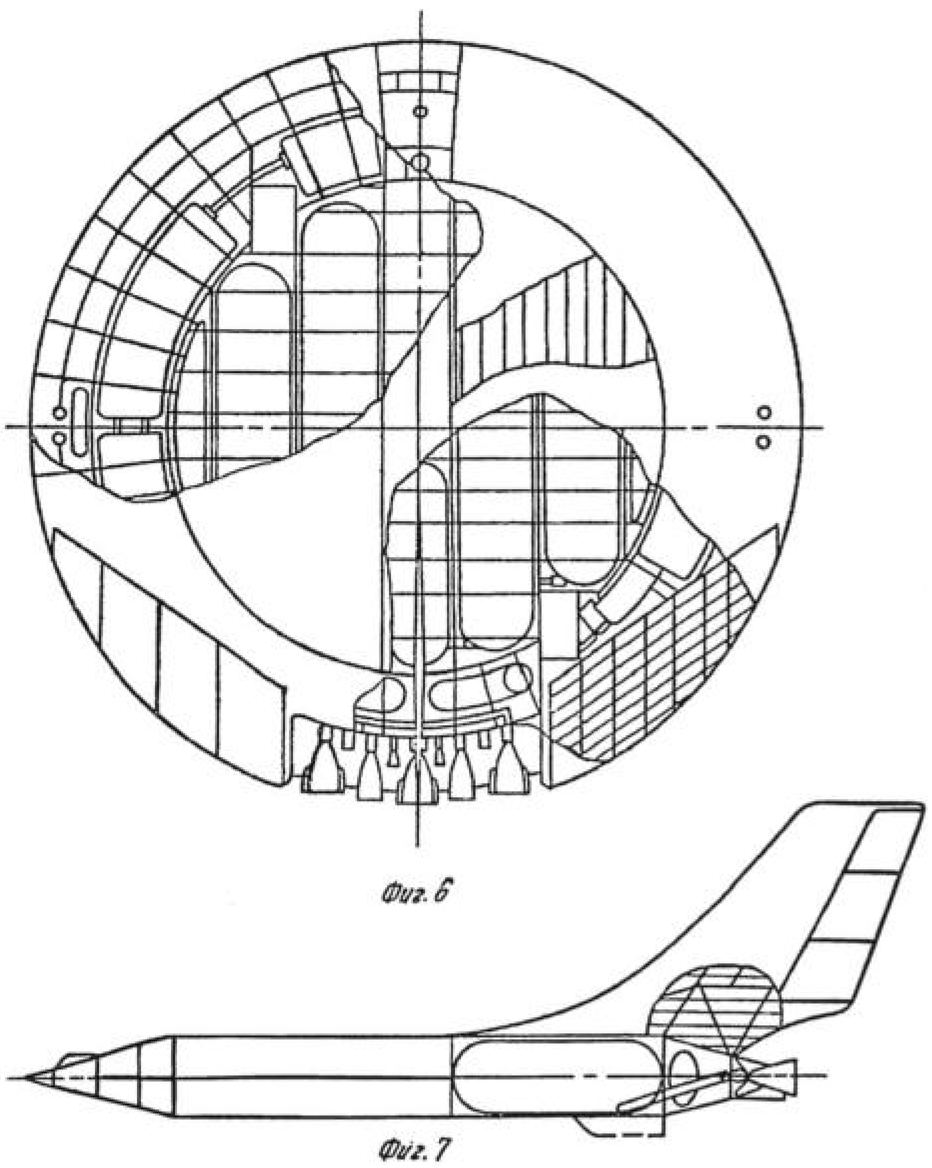


Фиг. 6

Фиг. 7

two large control surfaces along the trailing edge and a substantial tailfin allowed control during descent and landing. At the centre of the vehicle's underside was an area that appears to be a bomb bay and there was a fully retractable undercarriage consisting of four struts, each equipped with six wheels. Liquid-fuelled rocket engines powered the spacecraft and fuel would be stored in tanks that follow the circular shape of the vehicle. No doubt the Russians intended to use this craft at times of crisis as a flexible delivery system for nuclear-tipped space-to-ground missiles, or for global reconnaissance missions. Crew numbers and the mission duration are unknown although the option of an unmanned version was considered.

The Russians studied several different mothership concepts with various cockpit and engine layouts. Drawings show two large fins on the upper and lower surfaces of the disc and either two or four liquid fuel rocket engines, often supplemented by a pair of turbojets. One design for a launch craft had a bullet-shaped cockpit protruding from the front of the disc, perhaps to facilitate improved visibility or allowing it to be used as an escape capsule. This Ilyushin mothership was also considered as a long-range high-altitude bomber or transport aircraft, usually powered by eight jet engines. It is very unlikely that any of these concepts progressed much further than an elementary design stage but the project is believed to have remained active until the end of the 1970s.

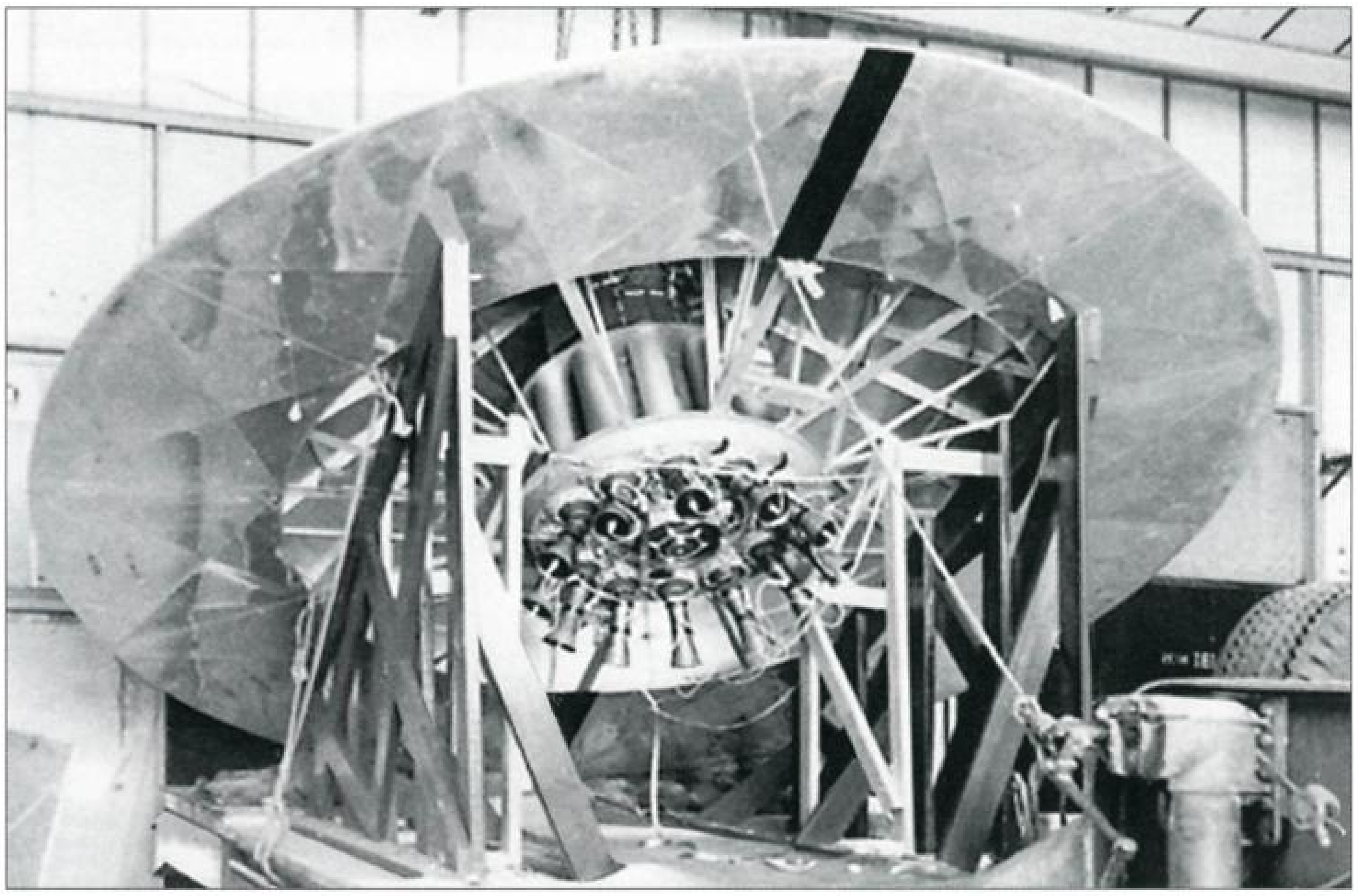
Planetary Aeroshell Trials

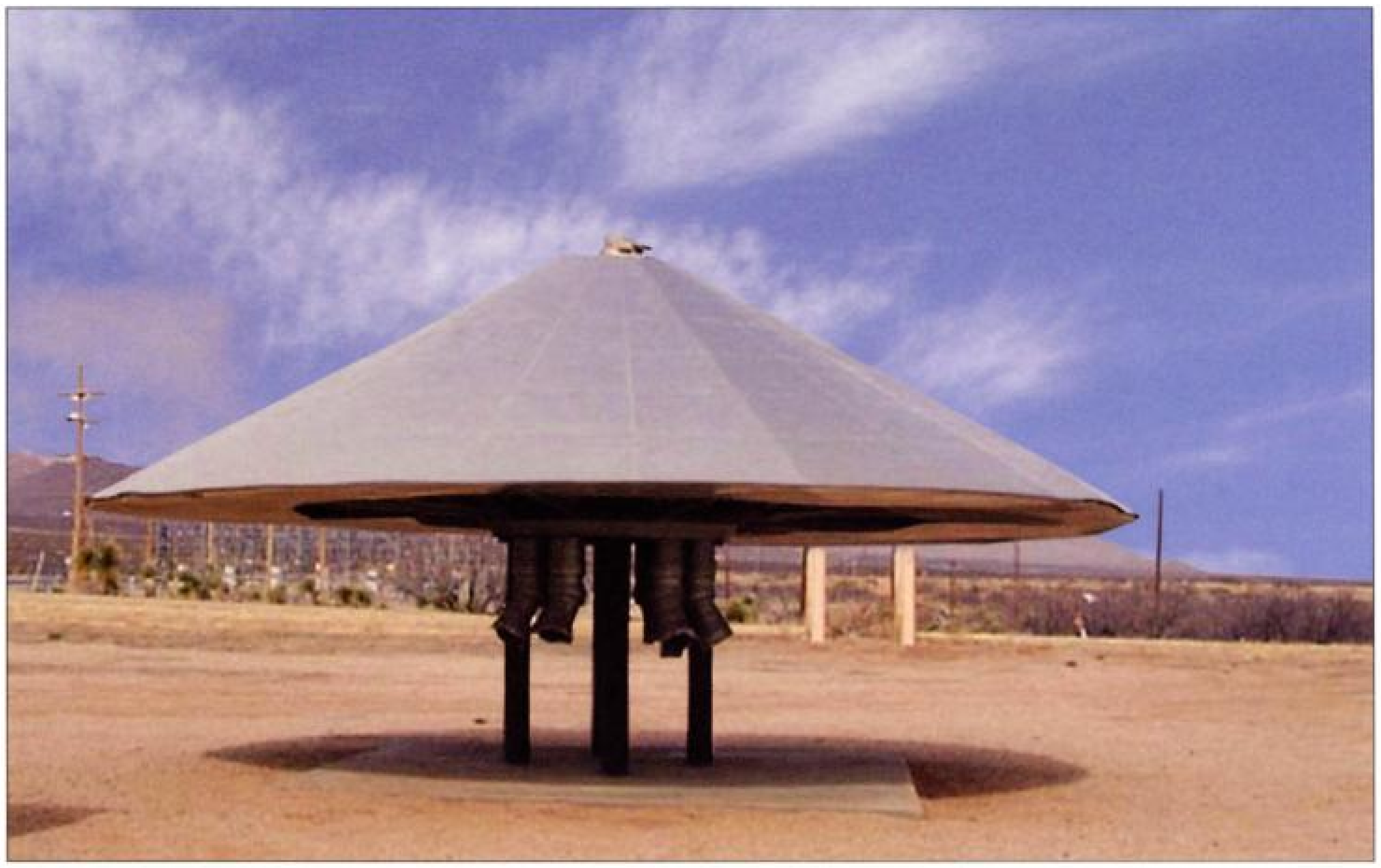
During the early 1960s, NASA's Jet Propulsion Laboratory at Pasadena, California started looking at ways to soft-land a robot spacecraft on Mars. Known as Project Voyager this ambitious project would later be re-named Viking, with the title Voyager being re-assigned a robotic grand tour of the gas giants Jupiter, Saturn, Uranus and Neptune. But testing hardware for the Mars mission proved very difficult because the planet's carbon dioxide atmosphere was found to be far thinner than scientists once believed. This was discovered on 14th July 1965 when NASA's Mariner 4 probe passed behind Mars and radio signal occultation showed that atmospheric density at the surface was less than one per cent of that found at sea level on Earth.

So the only easy way to undertake atmospheric entry simulations was at extreme altitude, either using a rocket or a balloon to carry the test vehicle to a suitable height. With the operational details decided, test vehicles were designed and built by NASA Langley under a project called the Planetary Entry Parachute Program (PEPP), which was managed by John C McFall.

The first PEPP vehicle (also referred to as a flight unit) took the form of a 15ft (4.57m) saucer-shaped disc carrying various instrumentation packages and a parachute payload. Weighing 1,600 lb (725kg), it was equipped with a ring of twelve small Falcon TX-18 solid-propellant rocket motors, each producing a thrust of 3,400 lb (1,542kg), that would burn for 1.5 seconds. The idea was to lift the PEPP vehicle to 130,000ft (39,624m) using the biggest balloon ever constructed and, four seconds after release, to fire the rocket motors to accelerate the vehicle on an arcing trajectory that would reach approximately 160,000ft (48,768m) and peak at about Mach 1.2. Although the release from the balloon was controlled using a ground command, there was no telemetry transmitted from the onboard instrumentation because this was considered an unnecessary complication.

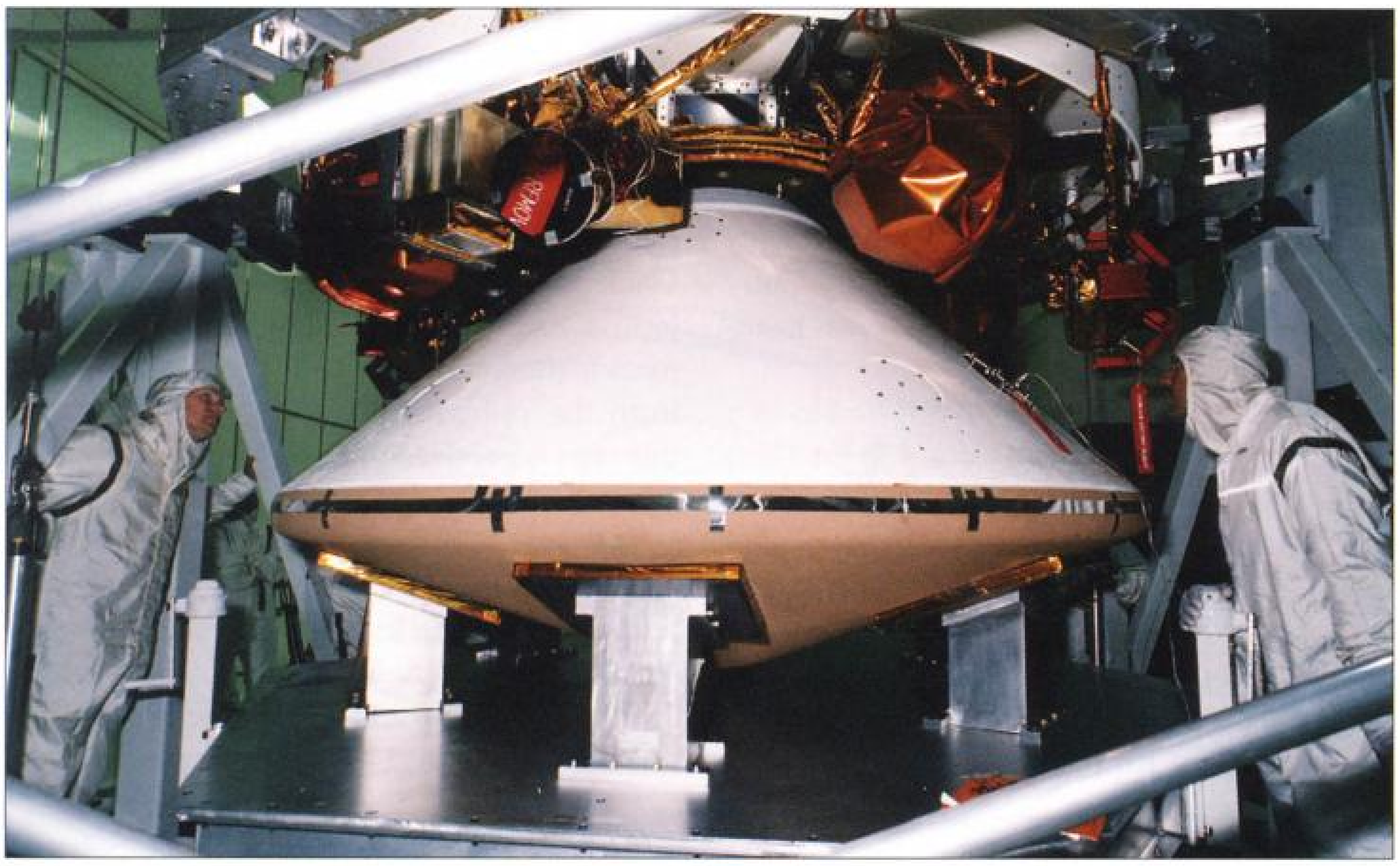
The first launch took place 30th August 1966 at Walker AFB, Roswell, New Mexico and the test vehicle was lifted by a massive 800ft (244m)-tall helium-filled balloon with a 26 million ft^3 (736,238 m^3) capacity that was specially fabricated by G T Schjeldahl Co. As



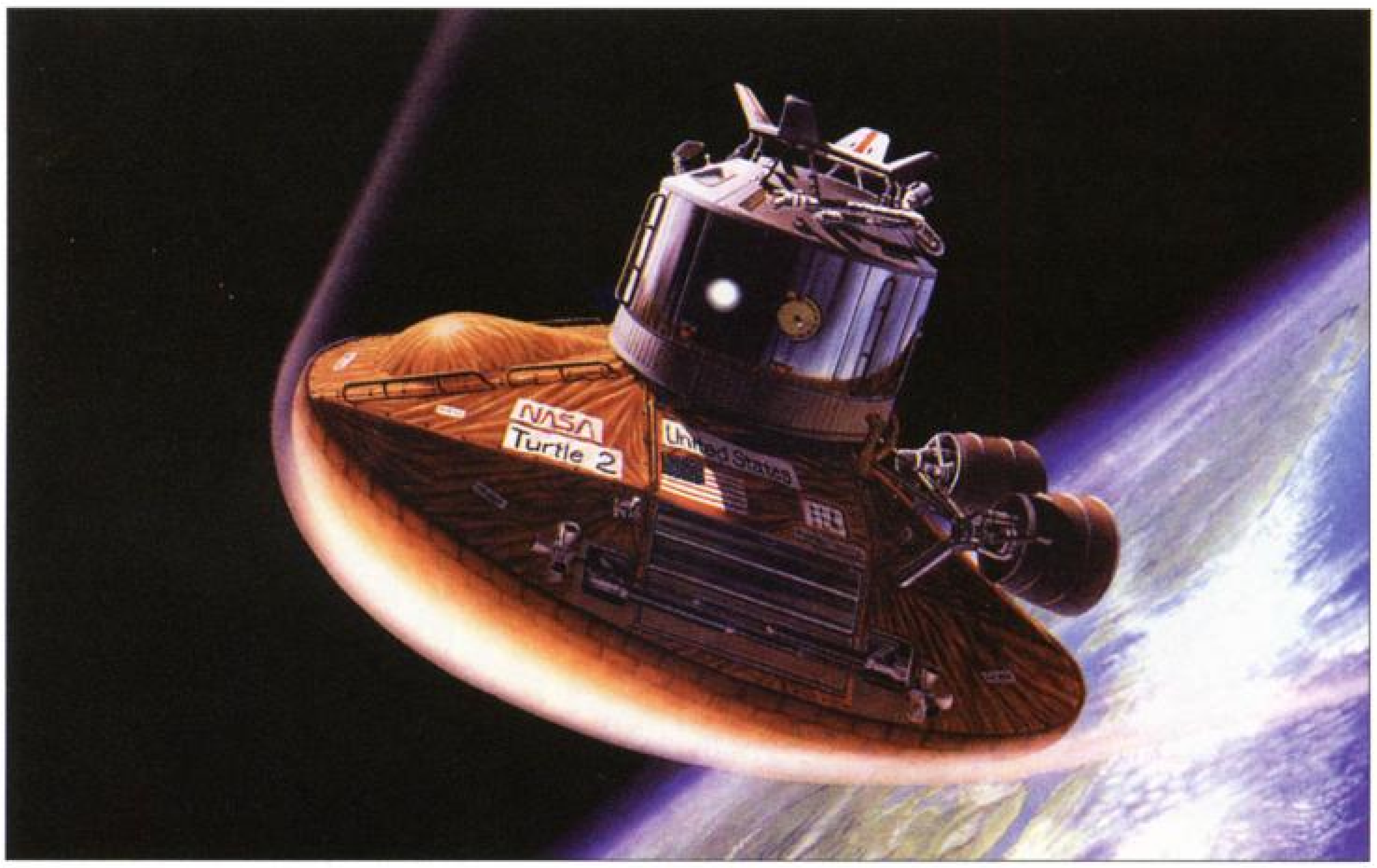


Above right: **Type 1 PEPP aeroshell showing the 12-rocket motor installation.** NASA

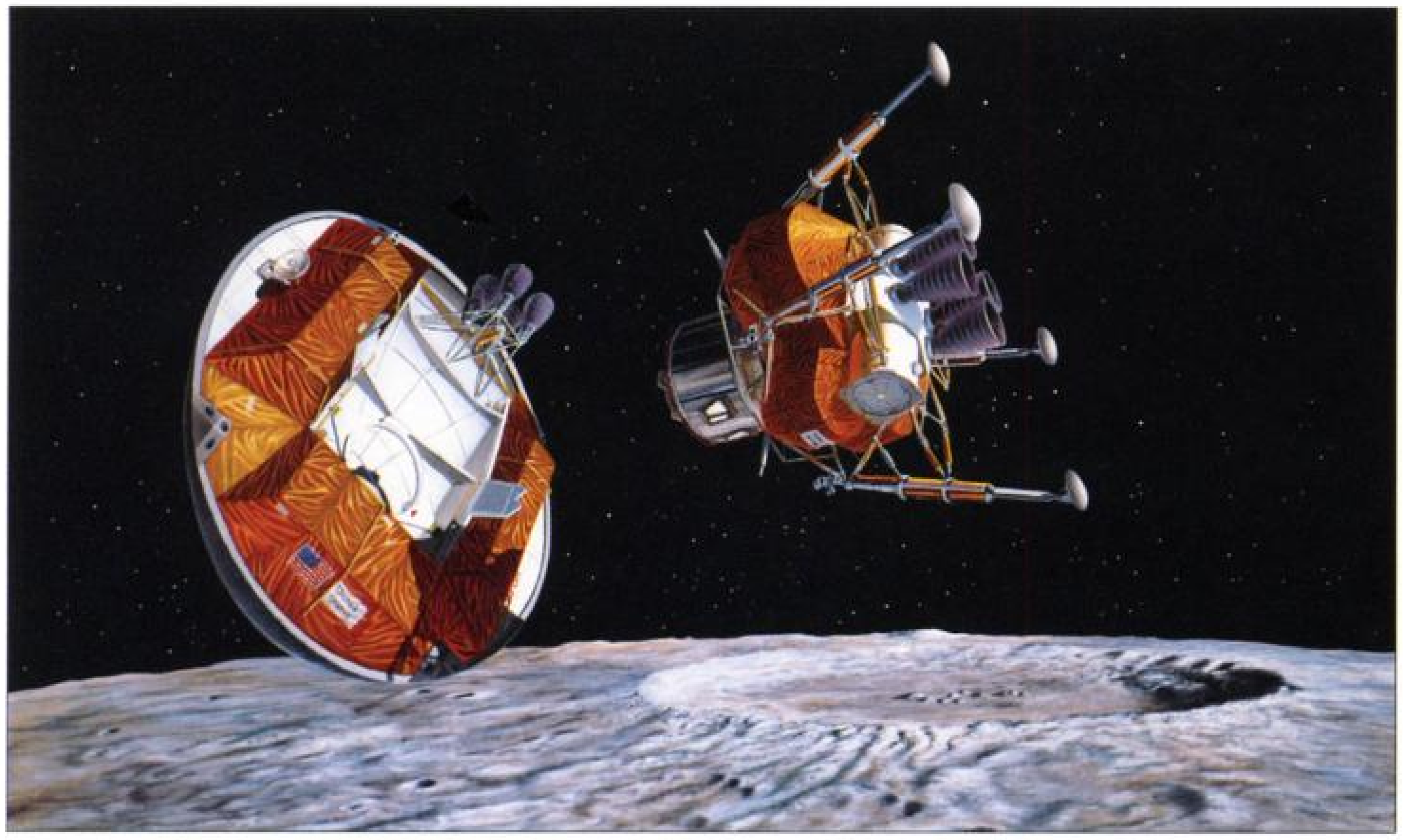
Right: **Type 2 PEPP aeroshell on display at White Sands Proving Ground.** NASA



Aeroshells are now a standard feature of spacecraft used to explore planets with atmospheres. In this photograph, NASA's Mars Pathfinder entry vehicle is mated to the cruise stage at the Kennedy Space Center's Spacecraft Assembly and Encapsulation Facility-2 (SAEF-2) during October 1996. Inside the protective aeroshell is the Pathfinder lander and contained within the lander is the Sojourner rover designed to explore a small area of Martian terrain. NASA Kennedy Space Center



Orbital Transfer Vehicle concept, seen 'aerobraking' through the Earth's upper atmosphere. NASA



Lunar Transfer Vehicle rendezvous with lunar lander in orbit above the Moon. NASA

planned the balloon drifted west towards the White Sands Missile Range (WSMR) and the flight unit was successfully released after two hours at exactly the right altitude. After a brief rocket burn, the aeroshell separated from the payload package and the 84ft (25.6m) parachute opened. This was formed from thirteen fabric rings with crescent-shaped vents to counteract excessive swinging.

The test firing had been conducted from almost the centre of the test area and the components all landed within the confines of the White Sands Missile Range. In total four flights were undertaken, with modifications taking place to the test vehicle. The main difference with the Type 2 vehicle was the switch to eight Sword-1 solid-fuel (Titan III C) booster separation motors. The fourth and final flight took place on 22nd August 1967. Although a fifth test was planned, it was cancelled by mission specialists who felt that they had more than enough data to move on with the programme.

This Type 2 test vehicle was eventually put on display at White Sands. It attracted widespread interest within the UFO community after it was spotted by a reporter called Paul Massa, who photographed it while he was working for the *Columbus Dispatch* in Ohio. Pictures appeared in print and this led to numerous suggestions that the unusual craft might have been responsible for flying saucer sightings over America's Southwest.

Surfing the Outer Atmosphere

During July 1984 NASA reached a series of conclusions about the best ways to fully utilise their forthcoming space station, which was expected to reach completion by the mid-1990s. With Marshall Space Flight Center taking responsibility for development of the Space Station's infrastructure, they awarded both Boeing and Martin-Marietta $1 million contracts to undertake fifteen-month studies

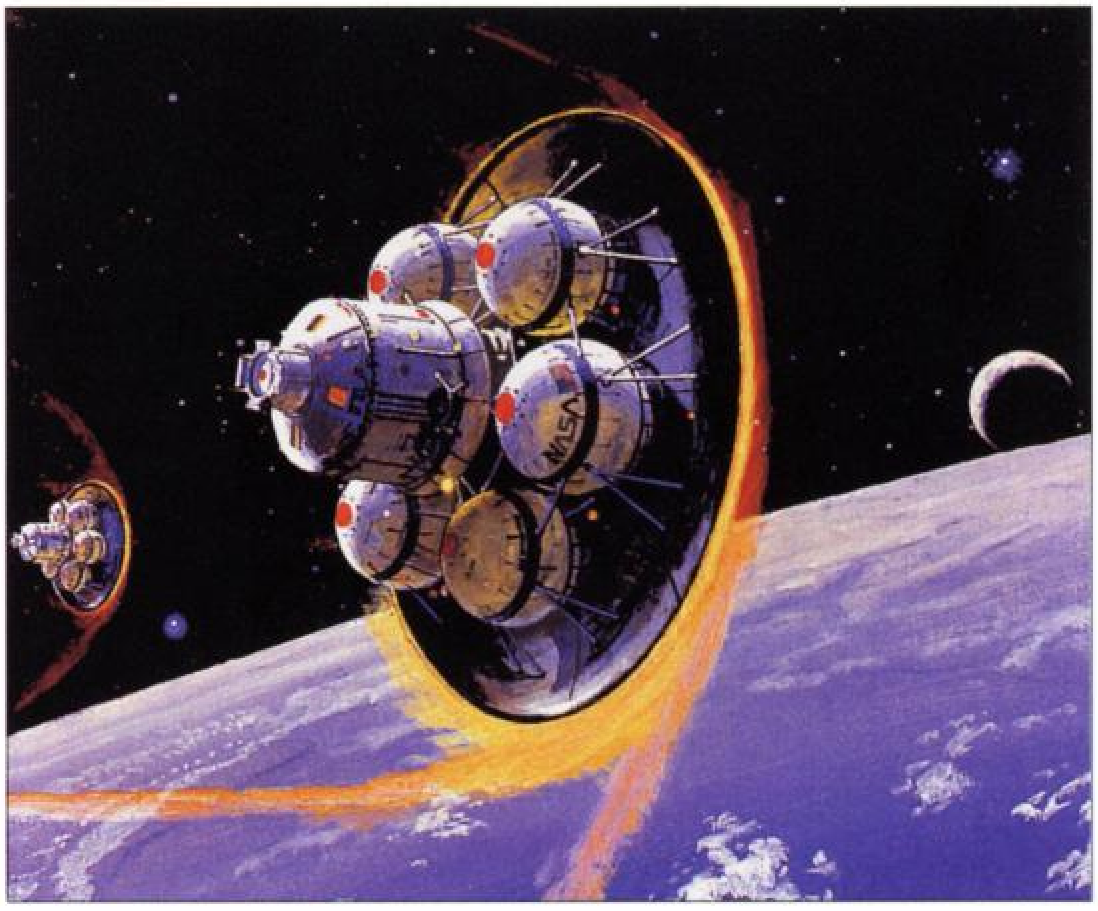
Orbital/Lunar Transfer Vehicle

(Design studies 1985-1989)

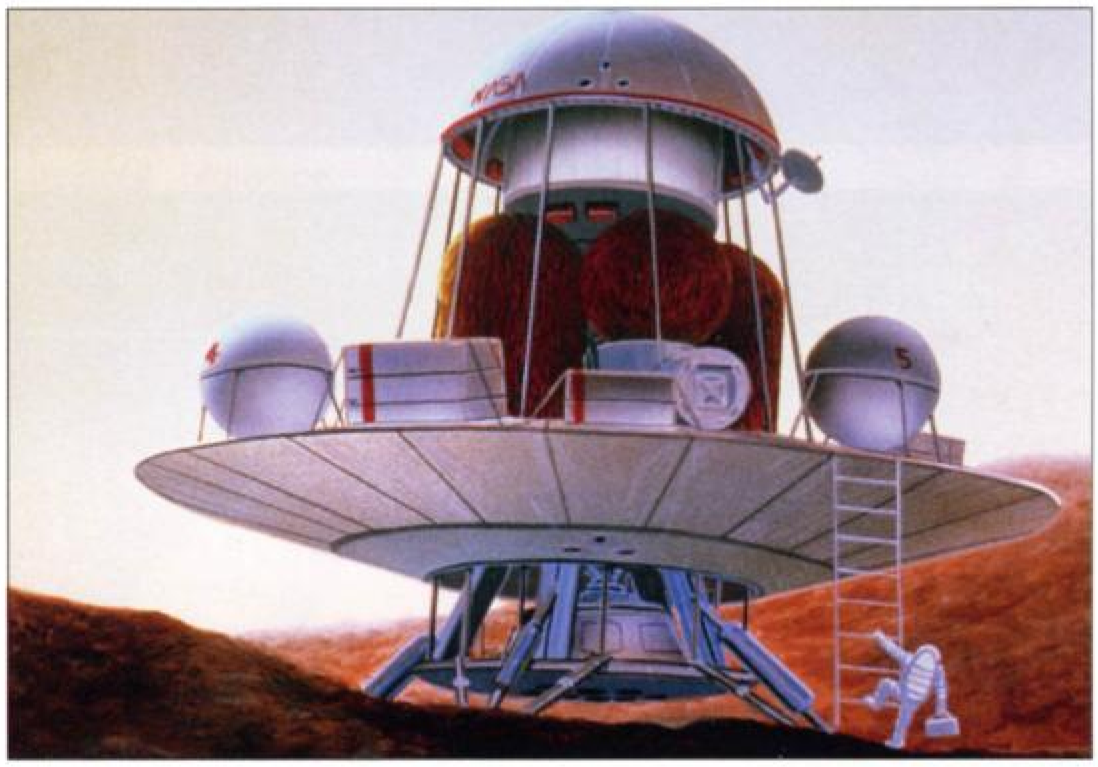
Role	Orbital/Lunar Transfer Vehicle
User	NASA
Contractors	Boeing, Martin-Marietta
Accommodation	Four to six astronauts in 12,125 lb (5,500kg) or 17,636 lb (8,000kg) passenger module
Dimensions	
Length	25ft 6in (7.77m)
Basic diameter	24ft 6in (7.47m)
Max diameter	38ft 0in (11.58m)
Weights	
Mass	82,783 lb (37,550kg)
Structure mass	2,804 lb (1,272kg)
Heat shield mass	1,552 lb (704kg)
Engines	
LTV version	4 x 20,000 lb (89kN) thrust AES engines
Propellant	LOX/LH2.
Heat shield use	Five missions before refurbishment at the space station.

Notes

In passenger-carrying form the LTV would rendezvous in lunar orbit with a 22,046 lb (10,000kg) six-crew lunar lander, or eventually dock with a space station orbiting the Moon. The LTV would also transport cargo payloads to the Moon, using expendable unmanned 16,755 lb (7,600kg) landers. For manned missions to geostationary orbit the OTV would be equipped with a specialised module using a robotic arm.



Above right: **Two OTVs returning from the Moon aerobrake through the Earth's upper atmosphere.** NASA



Right: **A 1989 NASA concept for a future manned Mars lander, which uses a fixed aeroshell for deceleration through the thin carbon dioxide atmosphere. This would be followed by the deployment of parachutes.** NASA

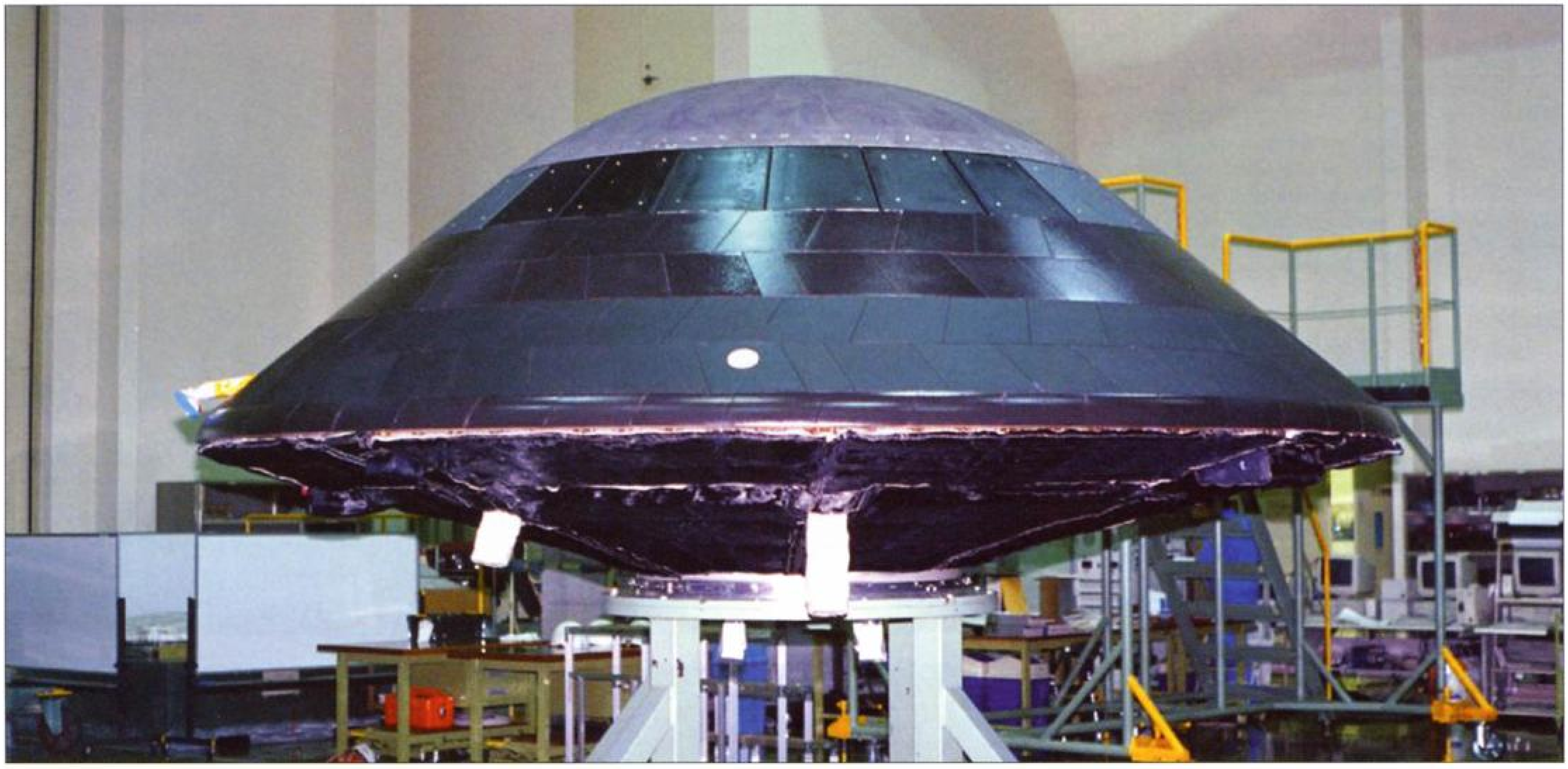
for a system of Orbital Transfer Vehicles (OTV) that would be based at the space station. These vehicles would be able to deliver and retrieve large satellites to and from geostationary orbit and undertake (in reconfigured form) longer-range missions to the Moon and beyond. The OTVs would become central to NASA's Moon plans, with vehicles being used to rendezvous with a lunar space station or dock with landers operating from a base on the Moon's surface. Such was the importance attached to a return to the Moon that in 1988 NASA renamed their OTV design the Lunar Transfer Vehicle or LTV.

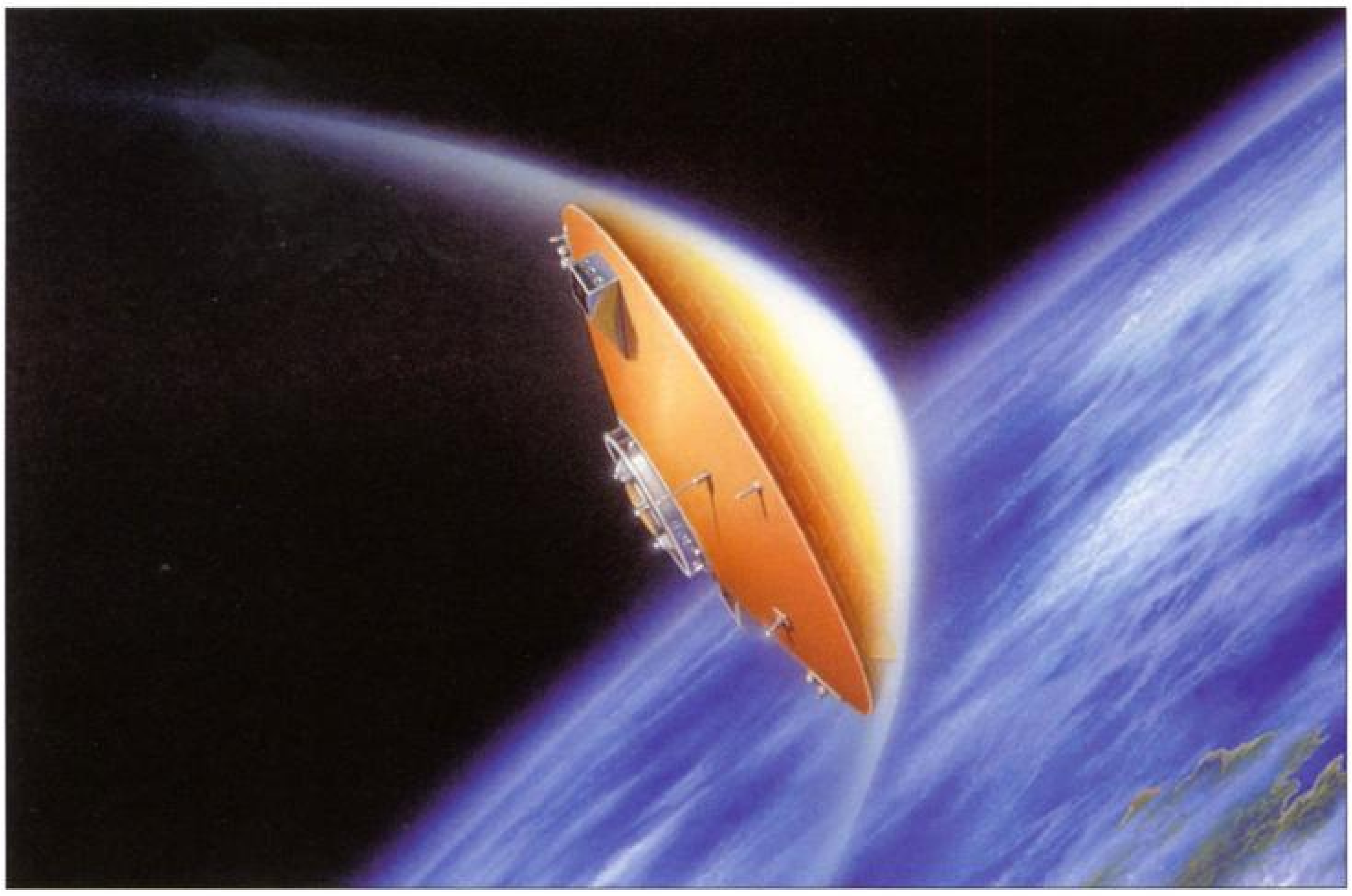
Working on proposals developed by Barney Roberts at the Johnson Space Center in 1984, NASA anticipated the establishment of a Moonbase by 2005, which would be expanded to accommodate a resident staff of eighteen by 2015. The base would be formed from a number of 17.5-ton (15,875kg) units derived from space station modules. They would be landed on the Moon's surface by expendable vehicles, launched from the Earth by a new heavy-lift booster called Shuttle-C. When the LTV system became operational manned Shuttles would dock with the Space Station and payloads would be moved to the OTVs for transfer to the Moon. Unmanned Shuttle-C rockets would lift supplies of fuel for the LTVs and it would be possible to deliver 18-ton (16,329kg) payloads from LEO to lunar orbit using two LTVs in tandem. Each of these vehicles would be equipped with a substantial saucer-shaped aeroshield, which would be used on return to Low Earth Orbit (LEO) to skim through the outer atmosphere and match orbits with the space station. Aerobraking would also permit the return of substantial payloads from geostationary orbit or the Moon without the need to burn fuel.

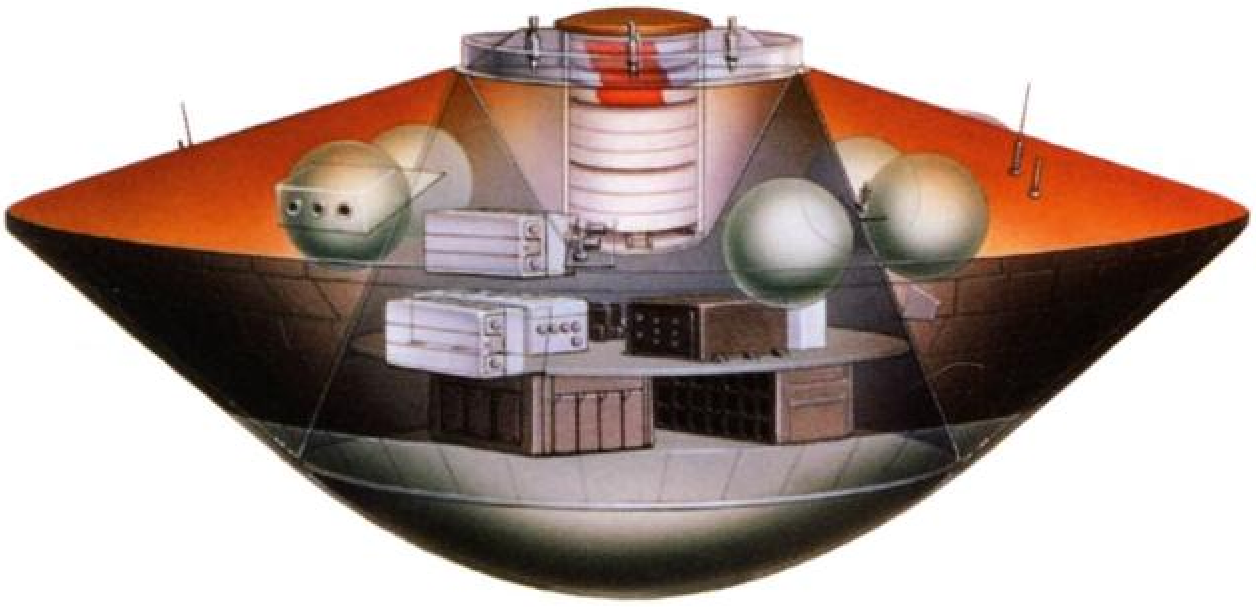
The possibility of using unmanned LTVs for long-range sample retrieval missions from Mars and Ceres was also considered during this series of studies and it was proposed to build some as expendable platforms without aeroshields. However, endless design revisions for the space station and a lack of political enthusiasm for a return to the Moon finally brought this series of interesting studies to an end in 1989.

OREX: Japan's Experimental Re-Entry Vehicle

The Orbital Re-Entry Flight Experiment (OREX) was the name of a small lenticular-shaped test vehicle with a diameter of 53in (134.5cm). It was built by the National Space Development Agency of Japan (NASDA), using an H-11 booster from the Tanegashima Space Center, and was launched on 3rd February 1994. OREX made a single orbit of the Earth at an altitude of 279 miles (450km) before four 150N hydrazine thrusters were used to de-orbit the craft and bring it back to Earth. Telemetry was received (aside from the period during communication blackout) by a ground station on Okinawa and, as OREX decelerated to







The Japanese designed and built Orex instrumentation capsule. Japan Aerospace Exploration Agency

Artwork showing the Japanese Orex instrumentation capsule undergoing re-entry. Japan Aerospace Exploration Agency

Orex instrumentation capsule showing internal details. Japan Aerospace Exploration Agency

supersonic speed, a parachute was deployed with the vehicle making a splash-down approximately 279 miles (450km) south of Christmas Island. The mission lasted two hours and thirteen minutes from launch and it was also the first test flight of the technically advanced H-11 launch vehicle.

The aim of this experiment was to demonstrate key technologies, which included an autonomous de-orbiting capability and thermal protection materials for use with later projects. The heat shield was formed from a carbon-carbon composite material at the centre and ringed by hardened ceramic tiles with the ability to resist 2,552° Fahrenheit (1,400° Celsius). These materials were bonded to a honeycomb aluminium alloy skin. Further useful data was gathered by monitoring the aerothermodynamic effects of ionised gas flowing around the vehicle. Japan had hoped to use this research project as the first stage in an ambitious spaceplane development programme but a series of failures plagued the agency for the remainder of the 20th century.

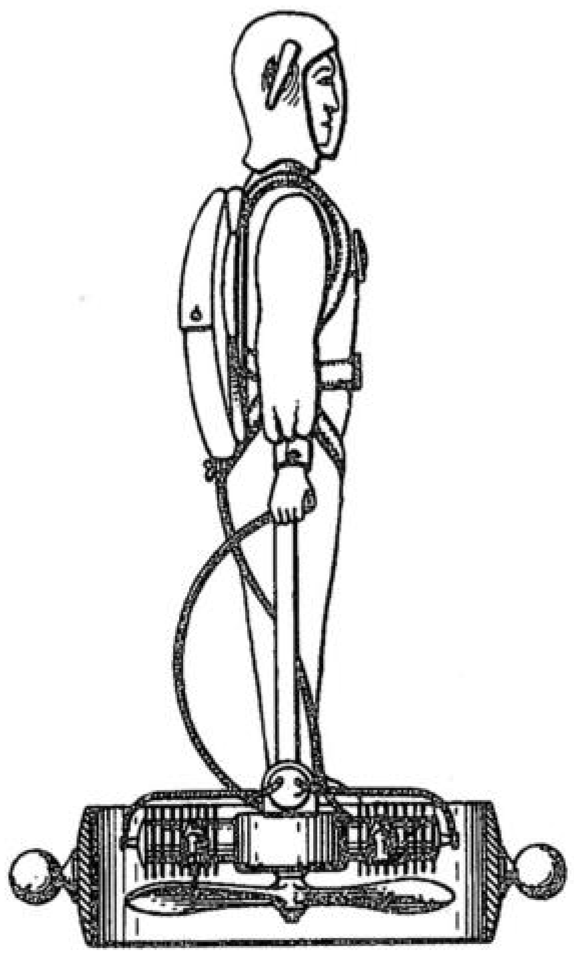
Chapter Eight

Fans and Ducts

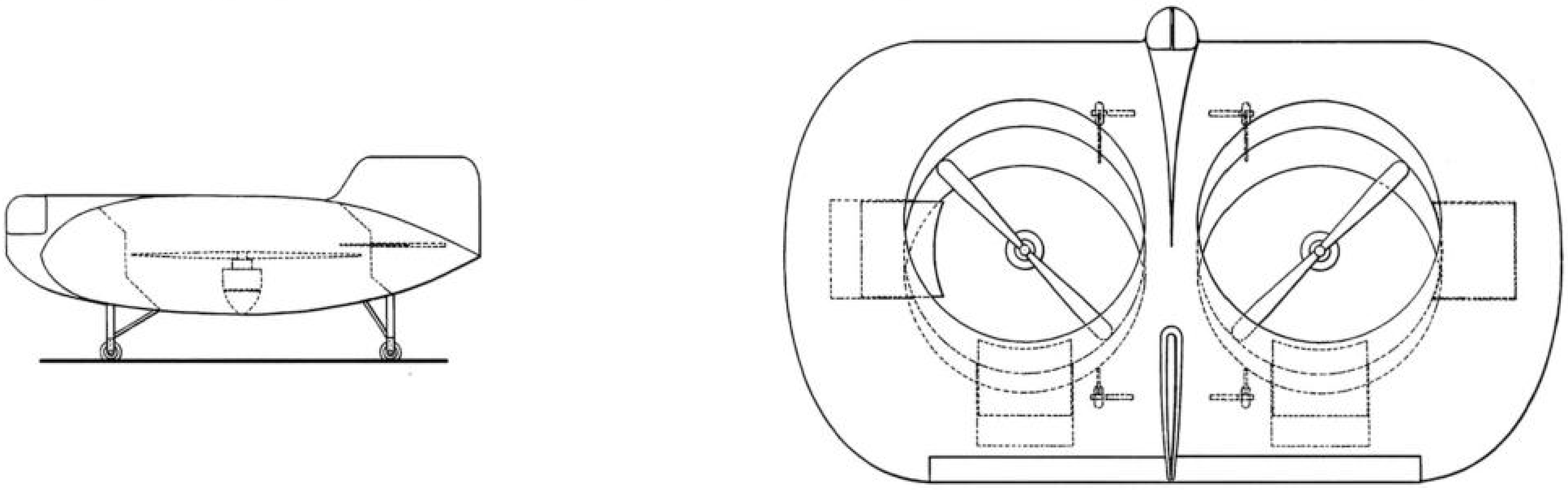
In 1935 Abraham S Fink of Aero Improvements Inc produced one of the earliest designs for a ducted fan VTOL aircraft. His concept for a flat-riser was expected to match the performance of a modern helicopter and it was propelled by two rotors in separate ducts driven by one or two internal combustion engines. Each rotor would turn in a different direction to counteract torque and movable vanes within the ducts provided control of the airflow and allowed transition from lift-off/hover to level flight. Supported by four landing legs (possibly retractable) the aircraft had a forward cabin to accommodate the pilot and a small number of passengers. Fink envisaged his aircraft as a light VTOL utility transport, but it never progressed beyond a paperwork study.

During World War Two German engineers combined the annular (ring) wing with ducted fan propulsion for advanced VTOL fighter concepts. In post-war America, some research conducted by Charles H Zimmerman at NACA Langley generated considerable interest in the possibility of building small personal flying devices that were capable of transporting military personnel on specialised short-distance missions. Zimmerman envisaged a compact machine, propelled by two rotors, that was steered by what Zimmerman called kinaesthetic control. This simply amounted to the vehicle's pilot shifting his body weight to change the direction of flight. It was hoped this technique would require little training and Zimmerman suggested it would be similar to riding a bicycle. Hiller, De Lackner and Bensen developed the idea further, producing ducted fan and propeller lifted platforms, but many safety and engineering concerns became apparent and these projects were finally abandoned. However, Aero Design & Development in Israel revived the concept many years later.

Throughout the 1950s a major European programme was undertaken to develop an annular-wing VTOL supersonic fighter, which was finally cancelled after a disastrous accident with the most advanced prototype. Development of the ducted-fan annular-winged aircraft then surfaced in America during the 1960s, when Convair produced detailed studies for a heavily armoured combat vehicle with visual similarities to some of the earlier French designs. This project was finally abandoned in favour of a more conventional attack helicopter, but ducted fan aircraft would return several decades later in the form of small vehicles like the unmanned Sikorsky Cypher drone and various advanced UAV designs.



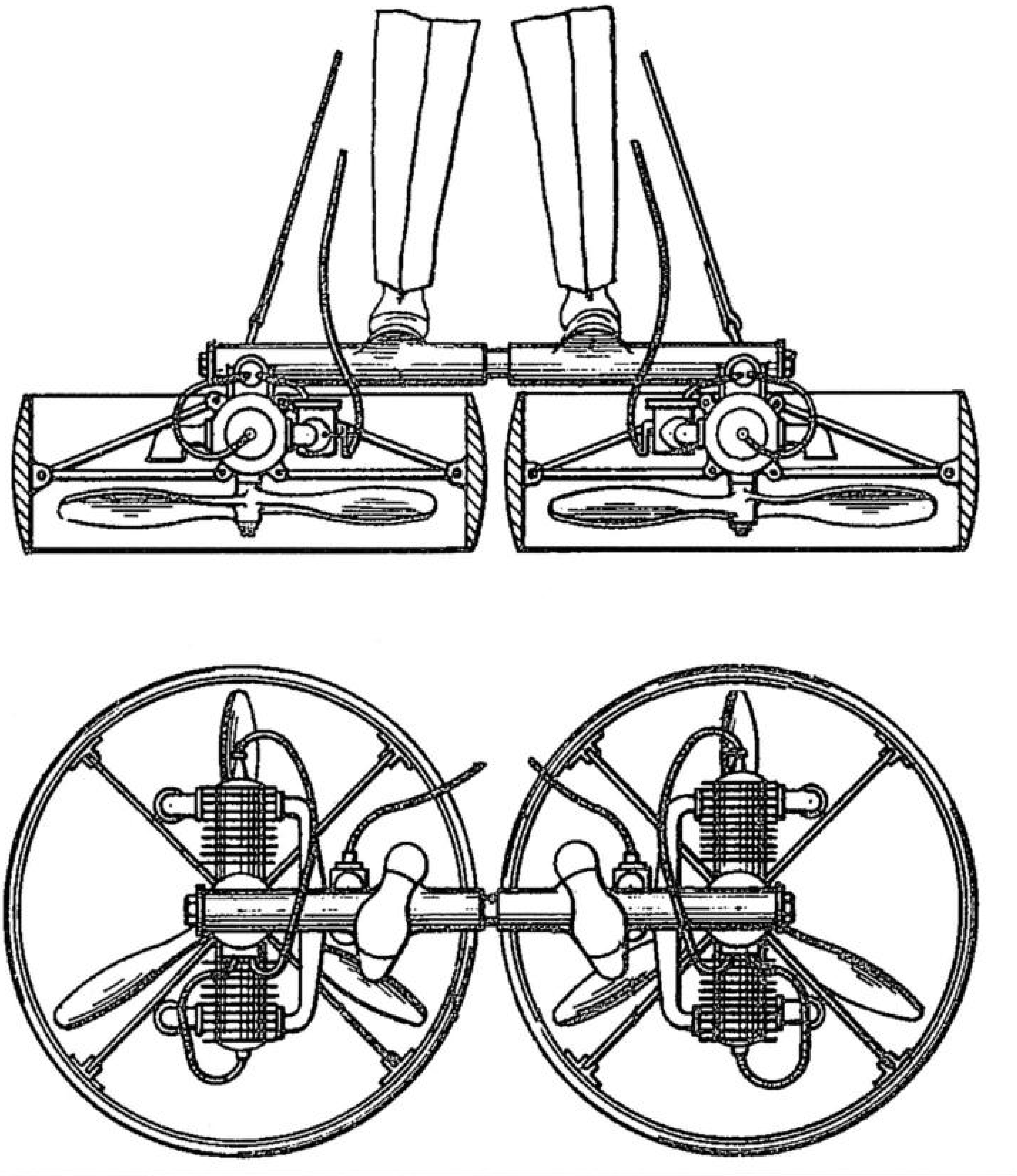
Side view of an early Zimmerman proposal for a one-man flying platform produced in 1947. via Bill Rose



A 1935 ducted fan VTOL aircraft design by Abraham Fink. US Patent Office

Zimmerman's Shoes

Having left Vought when the company relocated to Texas in 1947, Charles Zimmerman returned to NACA Langley where he started work on one of his own ideas that dated back to the early 1940s. Zimmerman wanted to produce a small VTOL flying machine that an average person could control with relative ease. This would be achieved by shifting body balance to direct pitch and roll: Zimmerman's kinaesthetic response technique. Initially it appeared that a high centre of gravity would make such a device unstable, but Zimmerman realised that placing the centre of gravity directly above the thrust axis would



Early drawings for a personal flying platform, produced in 1947 by Charles Zimmerman.
via Bill Rose

result in neutral stability. Consequently all the pilot needed to do was lean in the required direction of flight, which would make the platform tilt and move.

This led to the construction of a prototype vehicle based on his initial design called the Flying Shoes. It was a very basic proof-of-concept machine comprising two vertically positioned 65hp (48.5kW) four-cylinder, two-stroke engines (normally used for target drones) driving 30in (76.2cm) diameter three-blade rotors. Held together in a simple steel tubular framework and equipped with an upright pole for balance, Flying Shoes was tested on several occasions. It hovered about 12in (30.5m) above the ground but proved unstable due to problems of balance between the two engines, which could not be overcome by existing methods. Zimmerman improved the situation to some degree by fitting shrouds to the rotors, which created ducted fans, and this had the effect of boosting engine performance.

While technical difficulties with engine balance continued, during 1948 this research project came to the attention of Stanley Hiller (the head of Hiller Helicopters). He then purchased the rights to the Flying Shoes project and Zimmerman moved on to develop alternative ideas for small flying platforms. Hiller's own research programme follows shortly.

Zimmerman's next idea was to build a small personal VTOL device called the Jet Board, which had no engine but relied on thrust from gas bottles connected via two fire hoses. The compact steel-framed device measured 19in (48.3cm) x 29in (73.7cm) and had foot restraints for the pilot. Zimmerman made the first test flight on 2nd February 1951 and the platform proved to be outstandingly stable. Jet Board was never intended to be anything more than a technology demonstrator and, although Zimmerman experimented with onboard gas cylinders to facilitate very brief untethered flights, he soon began work on the construction of a third VTOL platform.

This was driven by bottled gas fed through fire hoses to a two-bladed rotor on the underside of the platform, with the air exhausting from the rear of the rotor tips. Given the name Whirligig, this platform had a diameter of 10ft (3.05m), a height of 3ft (0.914m), and used a rotor with an overall length of 7ft (2.13m). The prototype was considerably heavier than Jet Board, somewhat less stable and harder to control. The Whirligig made its first flight on 21st October 1953, but the platform was not a great success and the project was abandoned soon afterwards.

Personal Platforms

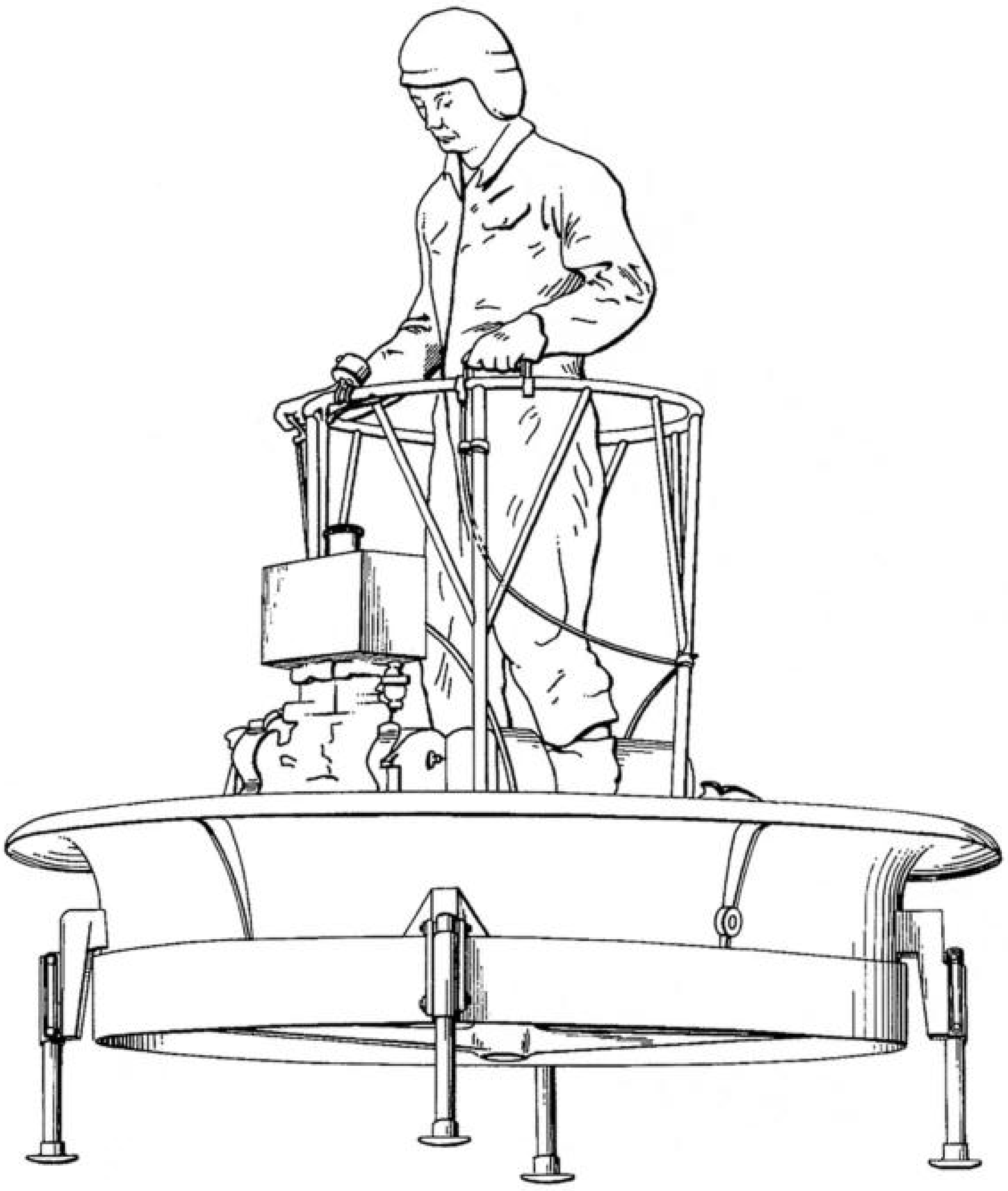
Having secured the rights to develop Zimmerman's personal air vehicle, Hiller Helicopters began a lengthy research programme to make the concept into something that would find favour with military customers. The company successfully promoted the idea of a one-man VTOL flying platform to the Pentagon and Hiller received a development contract on 17th September 1953 from the Office of Naval Research (ONR). This body also acted on behalf of the US Army and both were interested in using a small manned VTOL vehicle for special reconnaissance missions and light transport operations.

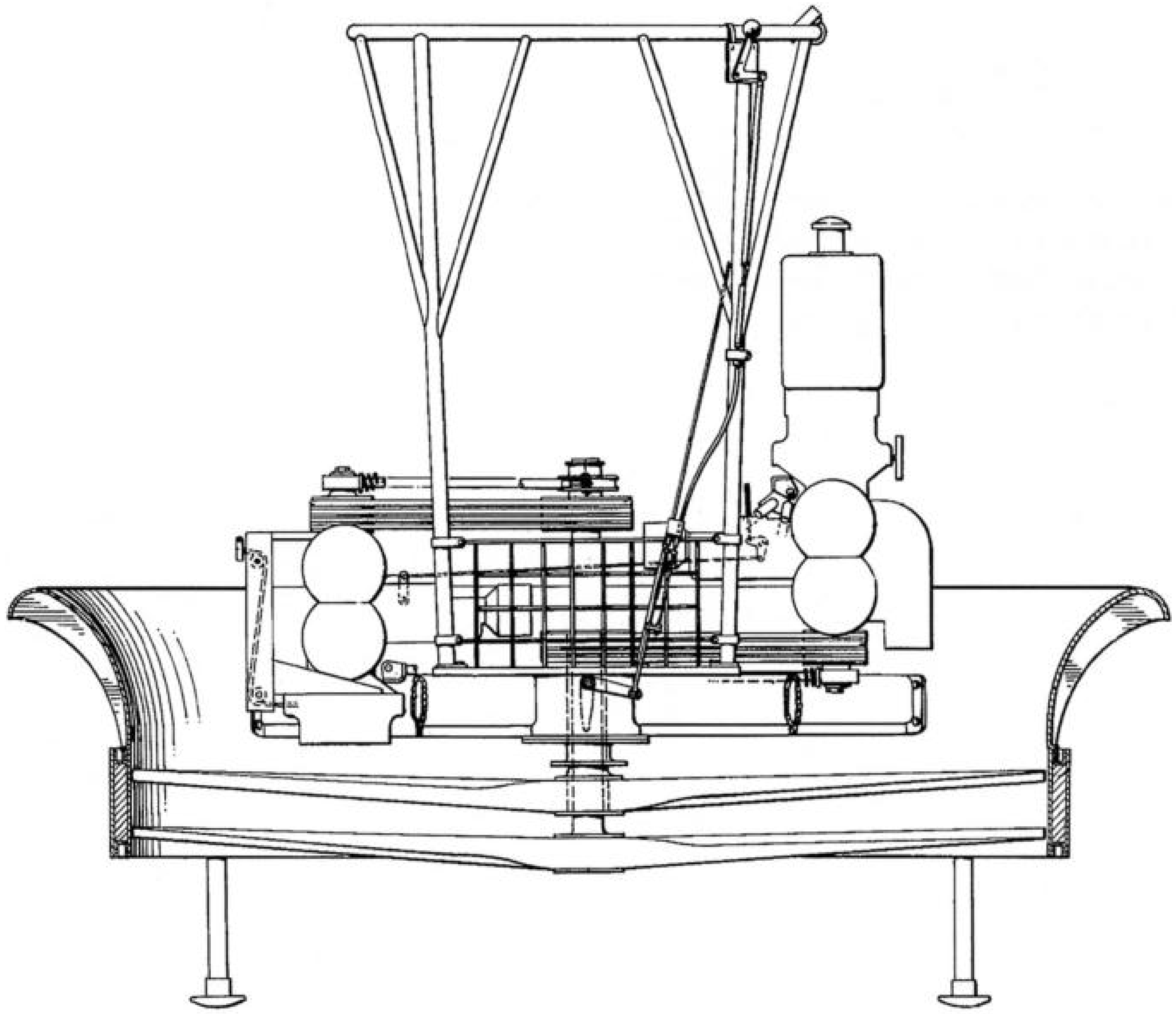
Once funding had been secured, Hiller started constructing the first prototype during January 1954, which was initially designated YHO-1 by the US Navy and classified as a secret programme. Completed in September 1954, but never issued with a serial number, YHO-1 (which was known within Hiller as Model 1031) made its first free test flight in January 1955 and the platform was then designated VZ-1 by the US Army. Given the less formal name Pawnee (a Native American tribe), VZ-1 consisted of a tubular steel and aluminium framework above a 5ft (1.52m) fibreglass shroud that enclosed two co-axial counter-rotating blades that were used for propulsion. Each of these was powered by a Californian-built Nelson H-59 two-stroke 4,000rpm engine, which produced 40hp (29.8kW).

The pilot stood upright on top of the platform within a railed enclosure and was secured by safety belts. Control of the vehicle was achieved with a motorcycle-style twist throttle, a torque adjuster and by using the method of body sway pioneered by Zimmerman to determine direction. When it was at rest, four landing legs were used to support

Original drawing for the Hiller VZ-1 one-man flying platform. Hiller Helicopters

Cross-section drawing of the Hiller VZ-1 flying platform. Hiller Helicopters





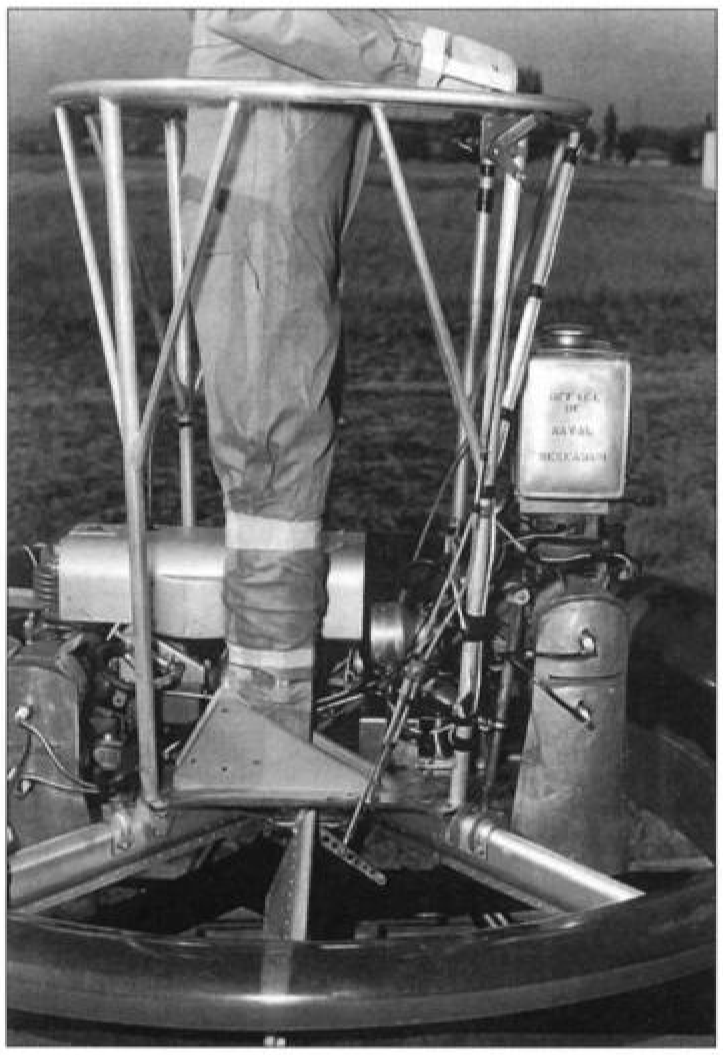
the vehicle. Hiller's chief test pilot, Philip T Johnston, undertook the first VZ-1 test flights and the platform performed well, demonstrating an ability to automatically right itself. However, there were handling difficulties in windy conditions and the machine could not exceed a speed of about 16mph (25km/h), or move very far out of ground effect.

In February 1956 the Hiller development team, which comprised Arthur Robertson, Joseph Stuart and Robert Wagner, filed a US Patent (2,953,321) for this design, calling it a VTO wingless flying platform. Nevertheless, it had many shortcomings and the team suggested that the next version should be fitted with a new power transmission system that would allow both engines to drive both rotors. In the event of an engine failure this would permit a hard landing as opposed to a complete loss of control. Another proposed alteration would be the introduction of four movable vanes to give yaw control.

During November 1956 the US Army ordered a second prototype (56-6944) for evaluation, which was given the company designation Model 1031A. This second platform flew for the first time on 20th November 1957. It was a big improvement over the earlier design, but the platform could not move out of ground effect, stability remained a troublesome issue and there were kinaesthetic control problems due to the lower centre of gravity. Hiller's engineers tried to correct the stability problem by fitting a gyro-stabilisation system linked to the yaw vanes in an arrangement similar to that used on the Hiller UH-12 helicopter.

To address the kinaesthetic control issue it was decided to raise the pilot's position, but the problem was never fully resolved. Unfortunately there was still insufficient power to lift the platform above a height of about 5ft (1.52m) and a larger 8ft (2.44m)-diameter duct was specified, enclosing two 7ft (2.13m) rotors. A third back-up engine was fitted, because high loading on the rotors meant that autorotation was not possible, although this addition came with a significant weight penalty. On the other hand, with double the rotor area, there was an immediate improvement to range and payload capacity, along with less downwash and a significant reduction in noise.

A third prototype (56-6945) followed, which was called the VZ-1E. This had a much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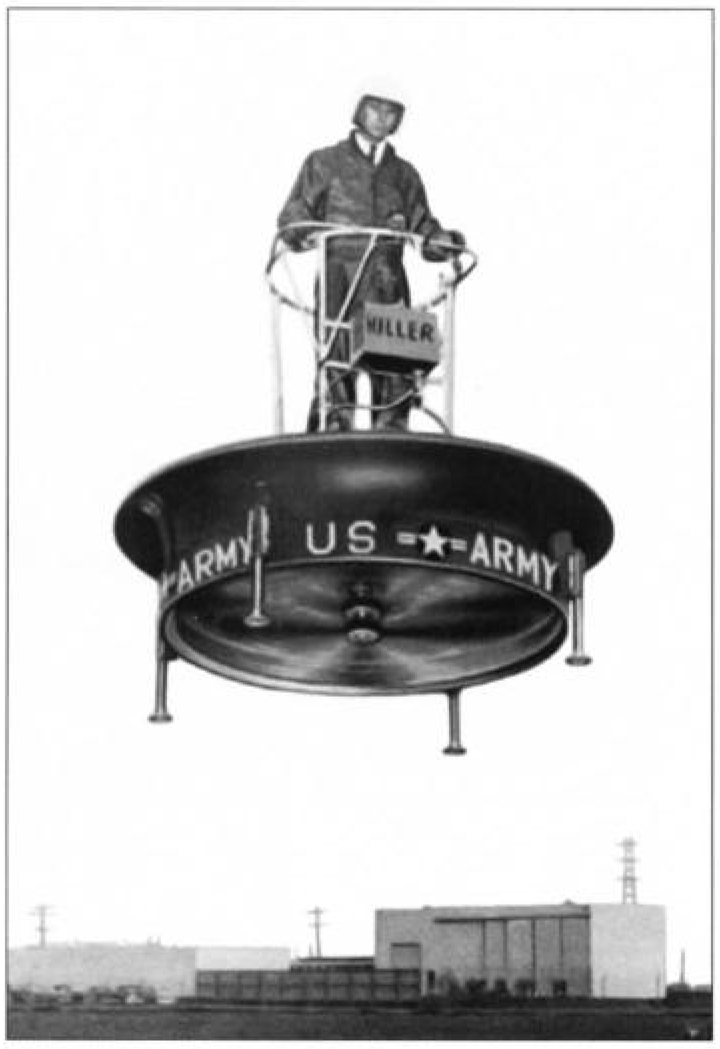
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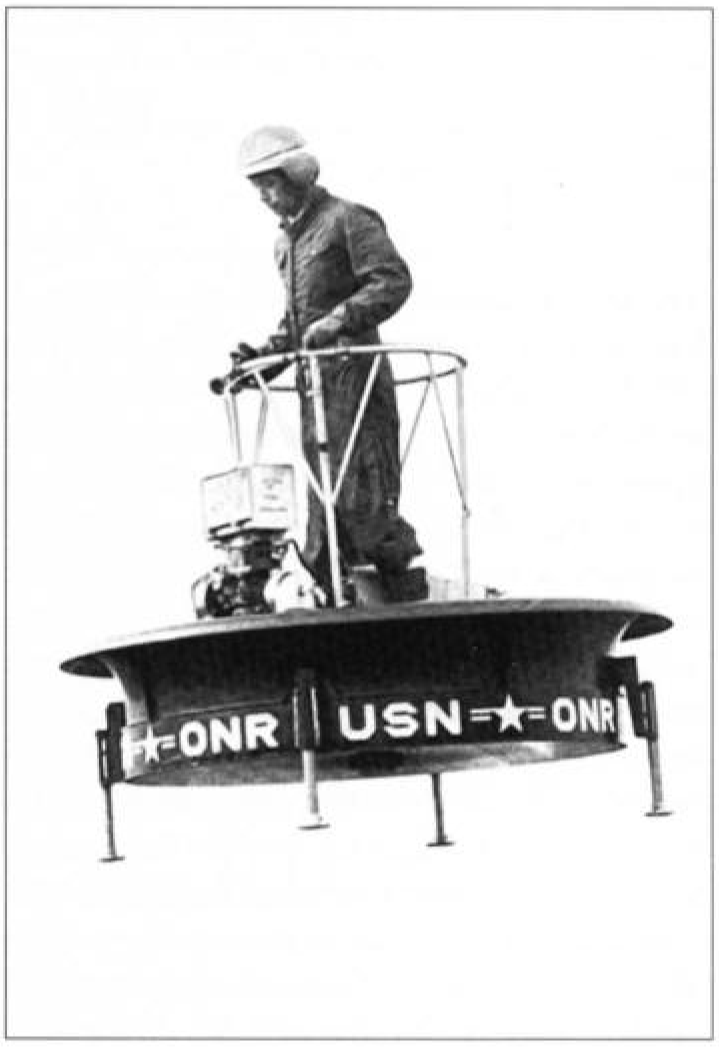
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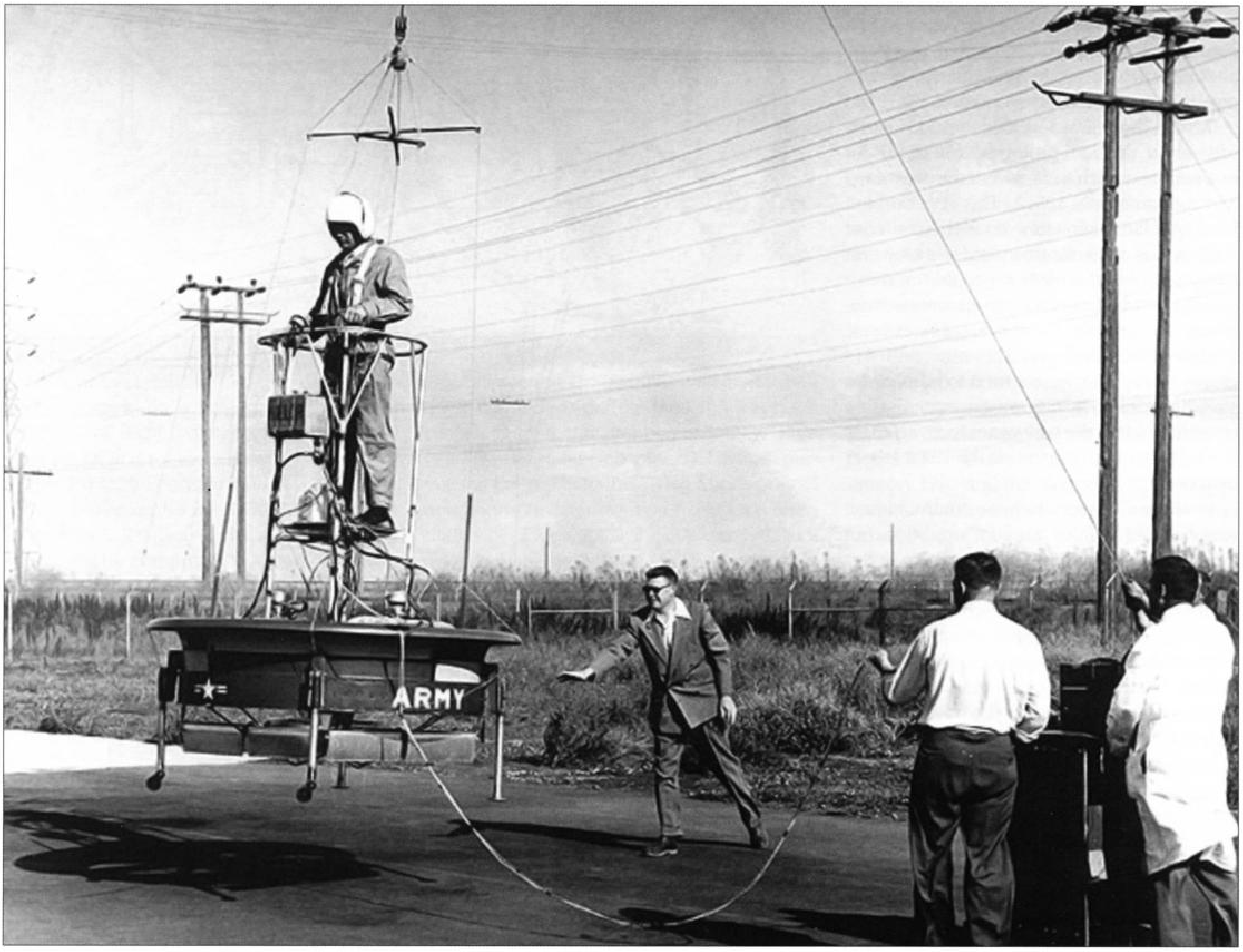
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Opposite page:
Left: **Pilot support section for Hiller VZ-1 flying platform.** US Navy

Centre: **The first prototype Hiller VZ-1 flying platform is put through its paces in 1955.** US Navy

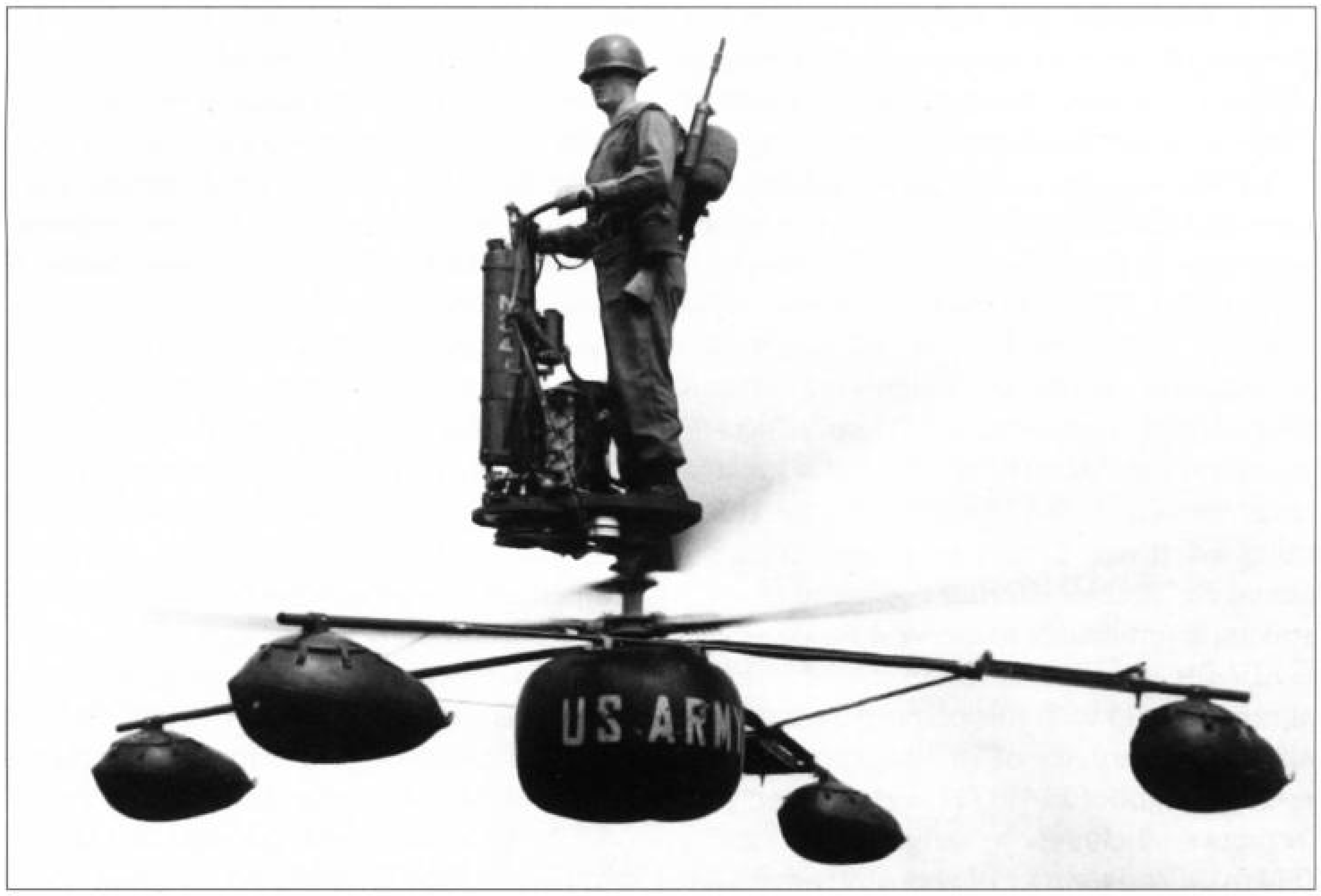
Right: **The Hiller VZ-1 Pawnee flying platform, photographed during a test flight in 1955.** US Navy

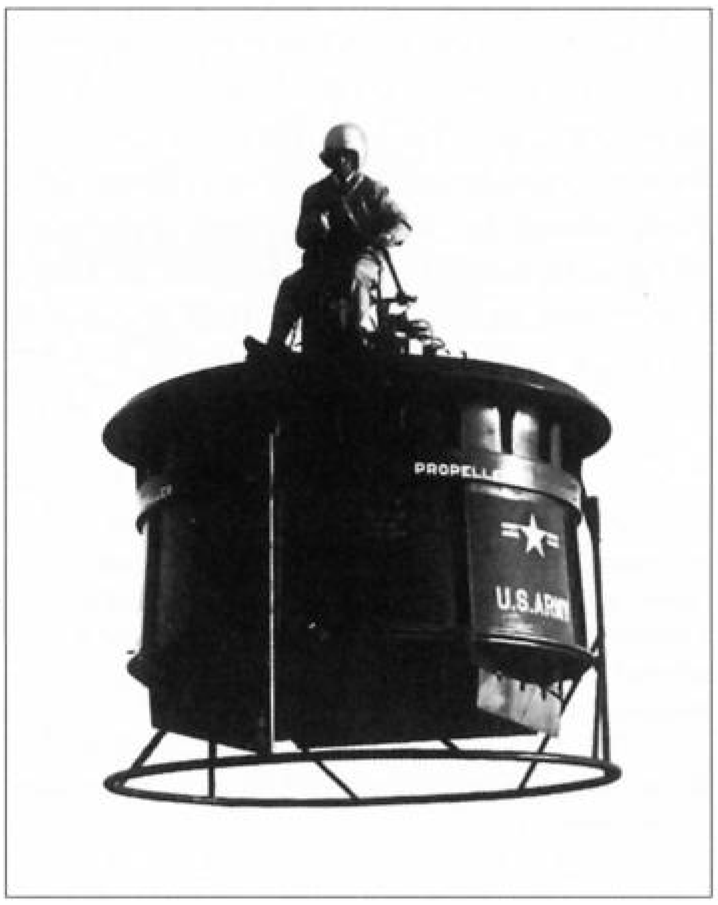
Bottom: **The second Hiller VZ-1 prototype undertaking a brief tethered test flight in late 1957 or early 1958. A number of modifications can be seen in this picture, including a raised pilot position to improve stability and control vanes below the rotors. Wheels have also been fitted to the forward struts.** Hiller Helicopters

This page:
Top: **The De Lackner Aerocycle, a competitor to the Hiller VZ-1, offering higher speed, although proving potentially dangerous to fly.** US Army

Right: **First flown in 1959, the Hiller VZ-1E flying platform was an extreme modification of the original design, using a deep duct and no longer controllable by means of body movement. VZ-1E proved unsatisfactory in most respects and the project was finally cancelled in 1963.** US Army

Far right: **US Army Captain Selmer A Sundby who undertook the De Lackner Aerocycle trials at Fort Eustis, from 1956 onwards. He was an experienced US Army test pilot who had undertaken more than 1500 hours on fixed-wing and rotary-winged aircraft. The De Lackner Aerocycle flights lasted from a few seconds to 43 minutes and there were two accidents, but Captain Sundby escaped without serious injury on both occasions.** US Army





deeper duct, a circular landing skid, flight controls that were more in keeping with a helicopter and a seat for the pilot (because kinaesthetic control was no longer effective). This platform flew in 1959 but it was apparent that these vehicles were too slow, difficult to handle, fuel-thirsty and susceptible to damage in a combat situation. Most of the advantages associated with the original design were now lost and the project was finally abandoned in 1963. The first flying platform is now with the Hiller Aviation Museum and the National Air & Space Museum has another VZ-1. According to Hiller six examples of this design were completed, but the fate of the other four remains unknown. The VZ-1 was briefly revived during the 1970s with ideas for using a gas turbine engine to drive the rotors, but this came to nothing.

Another one-man flying machine was developed during the early 1950s by the New York-based De Lackner Helicopter Company and it shared a number of similarities with the Hiller VZ-1 VTOL platform. Initially called the DH-4 Helivector, it was later renamed the HZ-1 Aerocycle. This machine was little more than a framework supporting a four-cylinder Mercury 40hp (29.8kW) outboard motor, which drove two 15ft (4.57m) contra-rotating rotors positioned beneath the platform. The pilot stood above the rotors and was secured in place with a harness. He controlled the vehicle with motorcycle-style handlebars fitted with a twisting throttle and by using body sway to direct the vehicle in the same manner as Zimmerman's Flying Shoes and the Hiller VZ-1. Landing gear consisted of one airbag directly below the rotors and four additional airbags at the end of booms, although this arrangement was later replaced with metal skids.

HZ-1 was significantly faster than the Hiller VZ-1 with an estimated top speed of 70mph (113km/h), a duration of one hour and a payload capacity (in addition to the pilot) of 120 lb (54kg). The platform first flew during January 1955 and was evaluated by the US Army who ordered twelve for development. Despite early claims that a complete novice could fly the platform, this does not appear to have been the case and HZ-1 was potentially dangerous when operated close to the ground and especially near rough terrain. Many test flights were conducted by Captain Selmer Sundby, who experienced two accidents while flying the HZ-1. In both cases these were caused by the collision of rotor blades, which flexed, made contact and disintegrated, leading to an immediate loss of lift. Fortunately, neither accident resulted in serious injury to Captain Sundby, who was awarded the Distinguished Flying Cross in 1958 for his evaluation of this aircraft. Nothing came of the HZ-1 and, although all twelve of these platforms were built, only one example remains in existence: on display at the Army Transportation Museum, Fort Eustis, Virginia.

A third design for a small personal flying platform was the Bensen B-10 Propcopter, which used two 4ft (1.22m) rotors, each driven by a McCulloch 72hp (53.6kW) engine. The machine was completed in 1959 and flown several times, but did not handle well and was abandoned. More recently, Aero-Design & Development (AD&D) in Israel has built a small circular VTOL platform called the Hummingbird. It was designed by the company's Managing Director, Dr Rafi Yoeli, and bears a striking resemblance to the VZ-1 Pawnee.

AD&D's intention is to tap into the recreational market with this platform, which has an overall diameter of 7ft 3in (2.2m) and an empty weight of 254 lb (115kg). Quoted performance includes a range of 31 miles (50km), an endurance of about forty-five minutes, a maximum speed of 27mph (43km/h) and a ceiling of 8,000ft (2,438m). Much of the vehicle is built from composite materials and the contra-rotating blades are driven by four 22hp (16.4kW) reciprocating engines, which utilise a digital electronic management system. Considerable attention has been paid to noise reduction and the platform carries an emergency parachute for use in the event of engine failure.

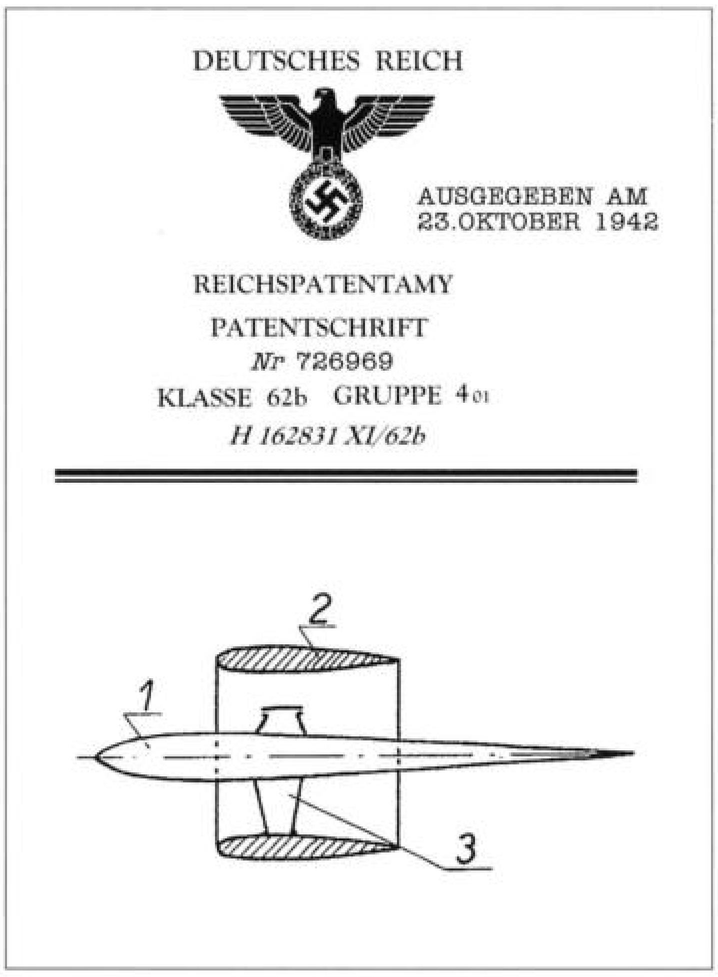
SNECMA

In the late 1940s a team of especially talented German scientists and aeronautical engineers came together as members of the Bureau Technique Zborowski (BTZ). These individuals had worked on some of the Third Reich's most advanced military aerospace projects and hoped to exploit their experience and knowledge in France. Heading this team was former Austrian SS Lieutenant Dr Helmut Graf von Zborowski (1905-1969), who controlled BMW's advanced ramjet and rocket development section at Berlin-Spandau until late 1944 when it moved to Bruckmühl near Rosenheim for the remainder of the war.

Many years earlier Zborowski had studied at the Aerodynamic Institute in Vienna, alongside his close friend Eugen Sänger who designed the first spaceplane based on realistic engineering and sound scientific principles. In 1934 Zborowski joined BMW in Munich and soon became a senior member of the company's management team. Amongst the projects he personally supervised was the Walter rocket engine for the Me 163B interceptor, a simplified replacement for the V-2 missile, possibly the development of a radial flow gas turbine (RFGT), and research into ramjets and annular (ring) wing concepts.

Following Germany's surrender Zborowski was interned at Prisoner of War Camp 317 near Göttingen. He was then released into French custody and taken to a chateau near Paris where he was extensively debriefed, along with many of his colleagues including Eugen and Irene Sänger. In 1947 Zborowski travelled to Bonn and recruited a team of highly skilled scientists and engineers. Members of his group had worked on cutting-edge ramjet and rocket-powered fighter projects, missiles and VTOL designs, believed to include the Heinkel Wespe and Focke-Wulf Triebflügel. Furthermore, they had continued to evolve some of these studies after hostilities ceased.

Their collective effort soon generated a number of interesting ideas for propeller/jet/ramjet-powered military and civil VTOL aircraft, which used compact bodies surrounded by an annular wing that formed the propulsion duct. This unusual configuration provided the same surface area as a typical conventional wing, while allowing major weight and dimension reductions, plus improved aerodynamics. The annular (ring) wing appears to have been conceived in 1942 by Werner Herrmann, who worked on mis-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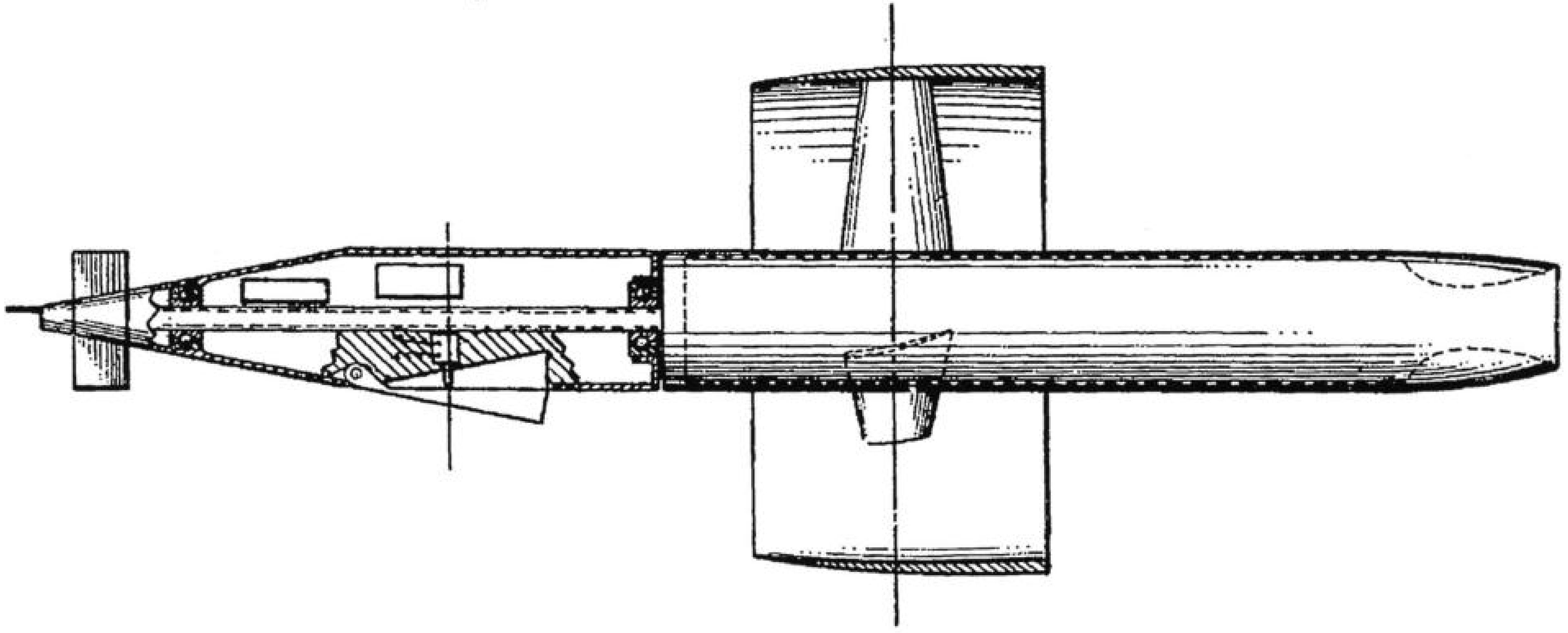
Right: **Wartime German patent for Herrmann annular (ring) winged projectile – sometimes called an aerial torpedo. This was produced in 1942 at Peenemünde and his initial idea was to extend the range of free-fall bombs.** European Patent Office

Below: **Herrmann annular wing design undertaken at Lockheed.** Lockheed



BTZ & SNECMA Ducted Fan VTOL Details

BTZ Hanneton (Cockchafer beetle) 1S

Type	Experimental VTOL Design
Accommodation	One (prone position)
Engines	Two Turboméca turboshafts
Propulsion	Contra-rotating two-blade, coaxial rotors

BTZ Hanneton (Cockchafer beetle) II

Type	VTOL light utility aircraft
Accommodation	Three (Pivoting seats)
Engines	Two Turboméca turboshafts
Propulsion	Two contra-rotating coaxial rotors. One two-blade, the other three-blade
Max speed	280mph (451km/h)
Range	620 miles (1,000km)
Length	18ft 6in (5.64m)
Diameter	19ft 9½in (6.04m)

BTZ Hanneton (Cockchafer beetle) III

Type	VTOL light utility aircraft
Accommodation	Five (pivoting seats)
Engines	Two Turboméca Marcadau II turboshafts
Propulsion	Two contra-rotating three-blade coaxial rotors
Max speed	400mph (644km/h)
Max range	745 miles (1,200km)
Weight	5,291 lb (2,400kg)
Length	22ft 11in (6.98m)
Diameter	10ft 9½in (3.29m)

BTZ Hanneton (Cockchafer beetle) III-A

Type	Utility VTOL aircraft
Accommodation	Six (pivoting seats)
Engines	Two Turboméca Artouste III turboshafts
Propulsion	Two contra-rotating three-blade coaxial rotors
Max speed	373mph (600km/h)
Max range	1,490 miles (2,400km)
Weight	5,732 lb (2,600kg)
Length	16ft 5in (5.00m)
Diameter	13ft 8½in (4.18m)

BTZ Hanneton (Cockchafer beetle) IV

Type	Light Transport Aircraft
Accommodation	Twelve
Engines	One Double Mamba turboshaft

BTZ Hanneton (Cockchafer beetle) 7C

Type	Light Transport Aircraft
Accommodation	Seven
Engines	Two Turboméca Turmo III turboshafts
Propulsion	Two contra-rotating three-blade rotors

BTZ Hanneton (Cockchafer beetle) 20C

Type	Light Transport aircraft
Accommodation	Twenty in two separate fuselage units
Engines	Two turboshafts coupled to ducted fan unit
Propulsion	Two contra-rotating three-bladed rotors

BTZ Lucane (Stag beetle) Design A

Type	Light Transport
Accommodation	Twelve+
Engines	Two turboshaft
Propulsion	Two separate ducted fan units, each containing two contra-rotating three-bladed rotors

BTZ Lucane (Stag Beetle) Twin-fuselage Design 2

Type	Transport Aircraft
Accommodation	Twenty
Engines	Four turboshaft
Propulsion	Two contra-rotating co-axial four-bladed rotors

BTZ Scarabée (Scarab Beetle)

Type	Recon and ASW VTOL aircraft
Accommodation	Two
Engines	Four Turboméca Turmo IV turboshafts
Propulsion	Two contra-rotating, co-axial two-bladed rotors
Max speed	373mph (600km/h)
Endurance	Six Hours
Weight	16,093 lb (7,300kg)
Military payload	1,100 lb (500kg)

BTZ Bruche (Beetle) Fighter

Type	Ground-Attack Fighter
Accommodation	One
Engine	Atar 101 Turbojet, with afterburning and ramjet mode
Max speed	900mph (1,450km/h)
Length	27ft 6in (8.38m)
Diameter	8ft 6in (2.59m)

SNECMA Atar Volant (Flying Atar engine) C.400 P.1

Type	Unmanned VTOL test bed
Accommodation	None
Engine	Atar DV turbojet with 6,400 lb (28.4kN) thrust. Tested beneath a 115ft (35.1m) gantry
First tethered flight	October 1955
Weight	5,500 lb (2,495kg)

SNECMA Atar Volant (Flying Atar engine) C.400 P.2

Type	Manned VTOL Flying Platform
Accommodation	One (with ejector seat)
Engine	Atar DV turbojet
First free test flight	May 1957
Test Flown	June 1957 at the Paris Air Show
Weight	5,730 lb (2,600kg)

SNECMA Atar Volant (Flying Atar engine) C.400 P.3

Type	Manned VTOL test bed
Accommodation	One (Similar cockpit to later Coléoptère)
Note	Tested on railway rolling stock but never flown

SNECMA Coléoptère (Flying Beetle) C.450

Type	Prototype VTOL aircraft
Accommodation	One
Engine	Atar 101E-5V engine rated at 7,700 lb (34.2kN) static thrust
Length	26ft 4in (8.03m)
Diameter	14ft 9in (4.50m)
Wing area	304.6sq/ft (28.3sq/m)
Weight (max)	6,613 lb (3,000kg)
First Free Flight	May 1959
Note	9 flights undertaken before crash

SNEMCA Coléoptère (Flying Beetle) AP.466 (Version E)

Type	VTOL Fighter concept
Accommodation	One
Engine	Atar 101 plus rocket power
Weight	11,000 lb (4,990kg)
Length (excl landing legs)	24ft 6in (7.47m)
Diameter	9ft 9½in (2.99m)
Note	Studied in 1953 but never built owing to propulsion limitations. Alternative versions of AP.466 were considered, with various engines and cockpit layouts

SNEMCA Coléoptère (Flying Beetle) AP.503 G-7

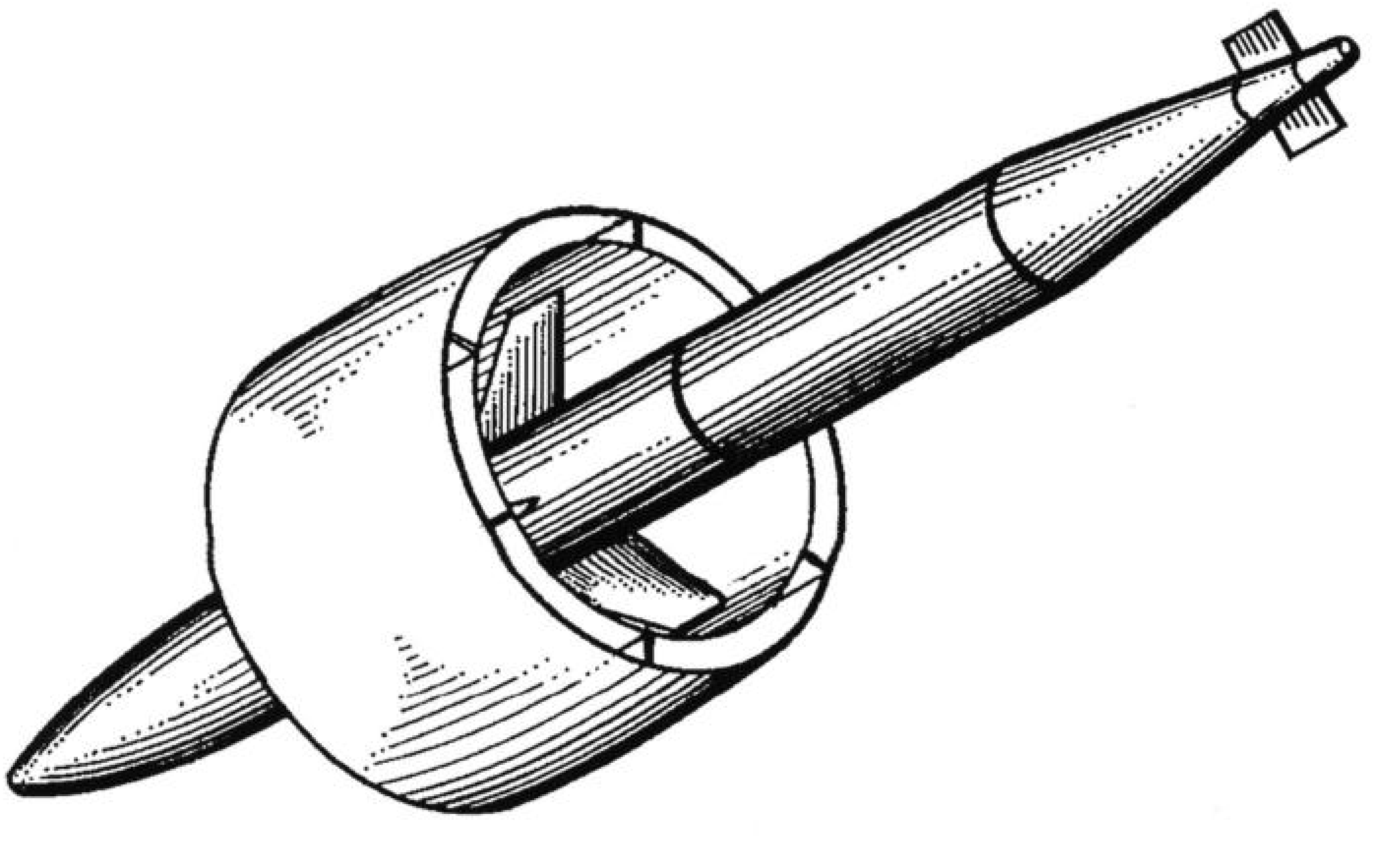
Type	VTOL Strike Fighter
Accommodation	One
Engine	Atar 101 G-32 with afterburner rated at 9,260 lb (41.2kN)
Max speed	680mph (1,094km/h)
Ceiling	49,000ft (14,935m)
Range	186 miles (300km)
Length	29ft (8.84m)
Diameter	8ft 6in (2.59m)

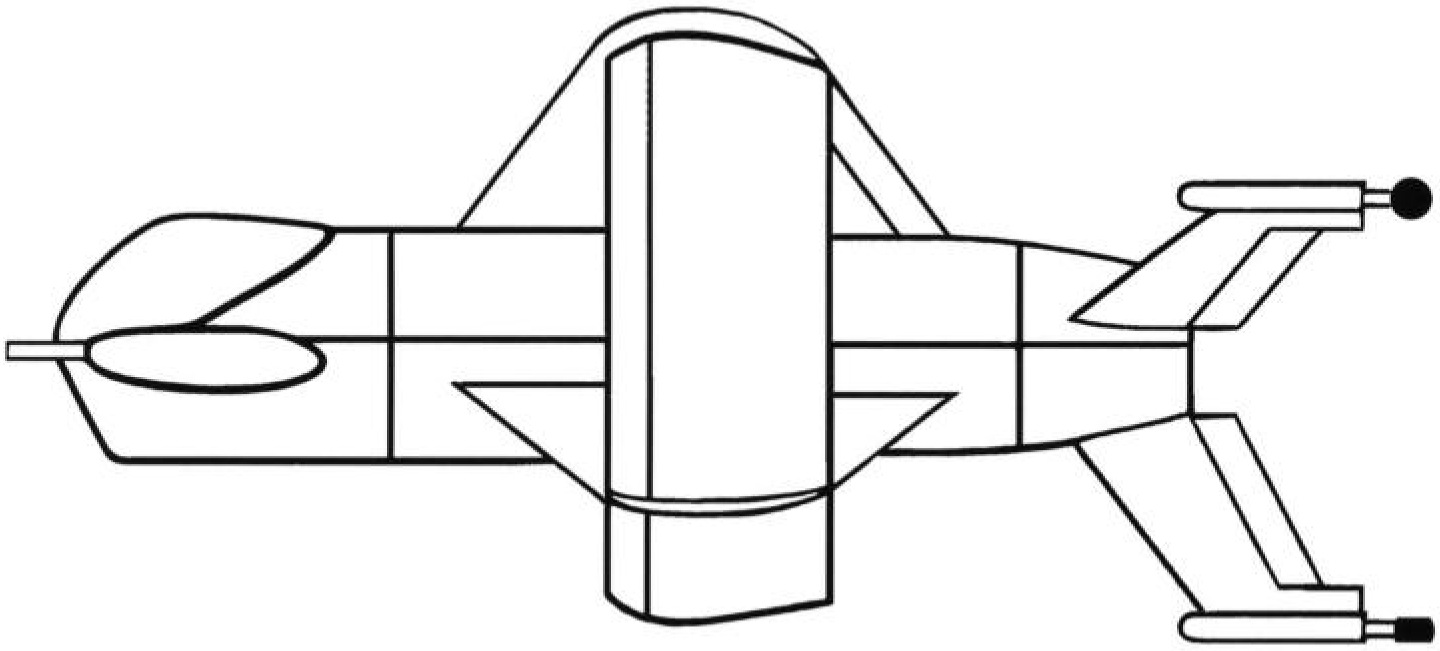
SNEMCA Coléoptère (Flying Beetle) AP.507E

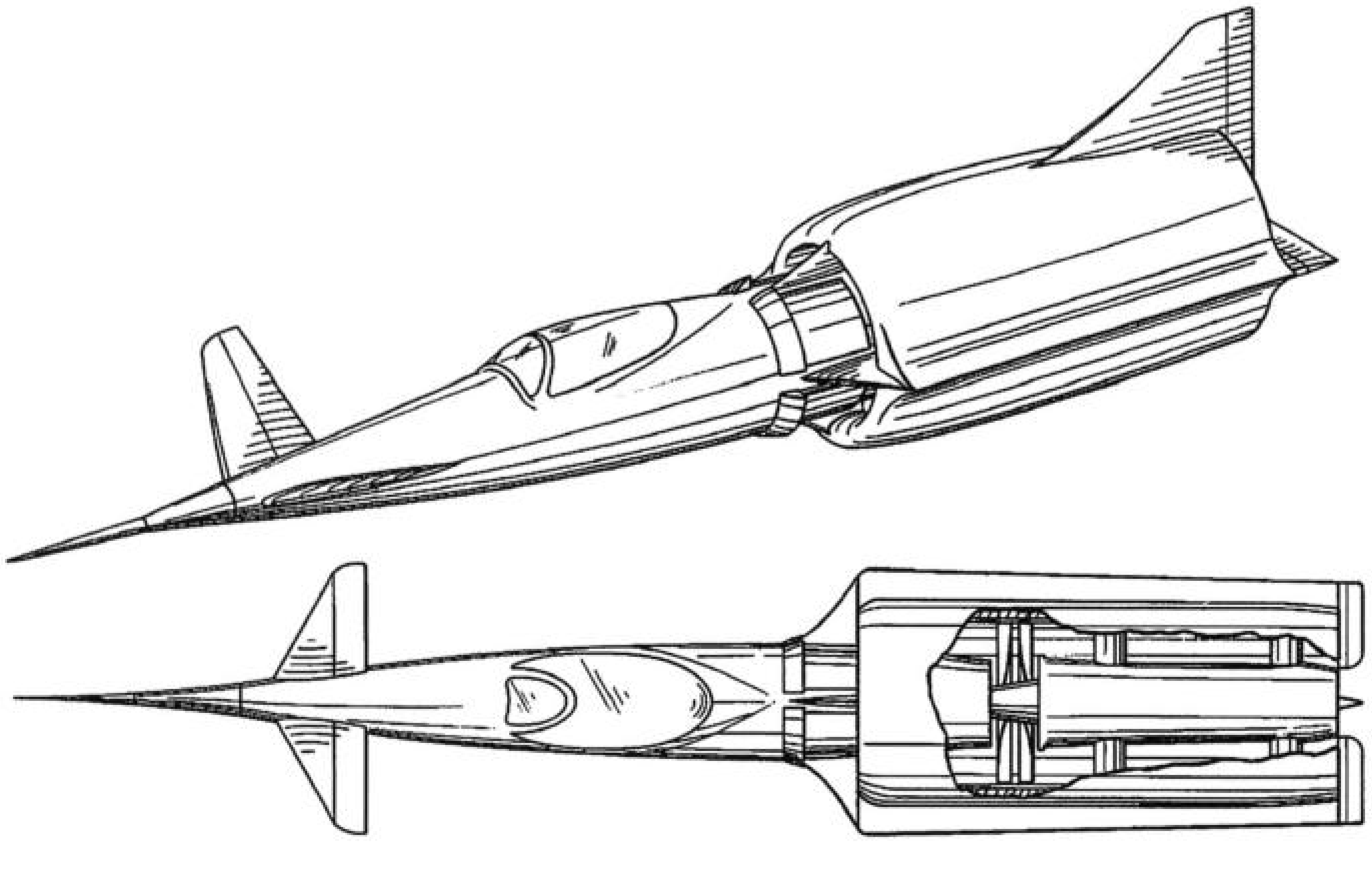
Type	VTOL interceptor
Accommodation	One (prone & conventional positions)
Engines	Unspecified, but with afterburning and ramjet function
Max speed	Mach 3
Ceiling	80,000ft (24,384m)
Range	560 miles (900km)
Weight	17,637 lb (8,000kg)
Length	36ft (10.97m)
Diameter	12ft (3.66m)

SNEMCA AP.519

Type	High performance VTOL interceptor
Accommodation	One
Engines	Two (SNECMA license built) Pratt & Whitney JTF10 (TF30)
Max speed	Mach 2+
Weight	16,579 lb (7,520kg)
Note	Intended to take off and land horizontally or vertically, AP.519 was SNECMA's last design for a VTOL fighter. A similar concept was explored by Focke-Wulf







Top to bottom:
Herrmann annular wing design undertaken at Lockheed. Lockheed

Heinkel Wespe ducted-fan VTOL fighter concept developed in 1944 at Vienna. This proposal had been replaced by a more satisfactory design called Lerche by the time hostilities ceased. Bill Rose

Lippisch design for high-performance annular wing, ducted fan aircraft. US Patent Office

sile development at Peenemünde (and eventually found employment with Lockheed's Skunk Works). He hoped this idea could be applied to glide bombs as a useful way of increasing range.

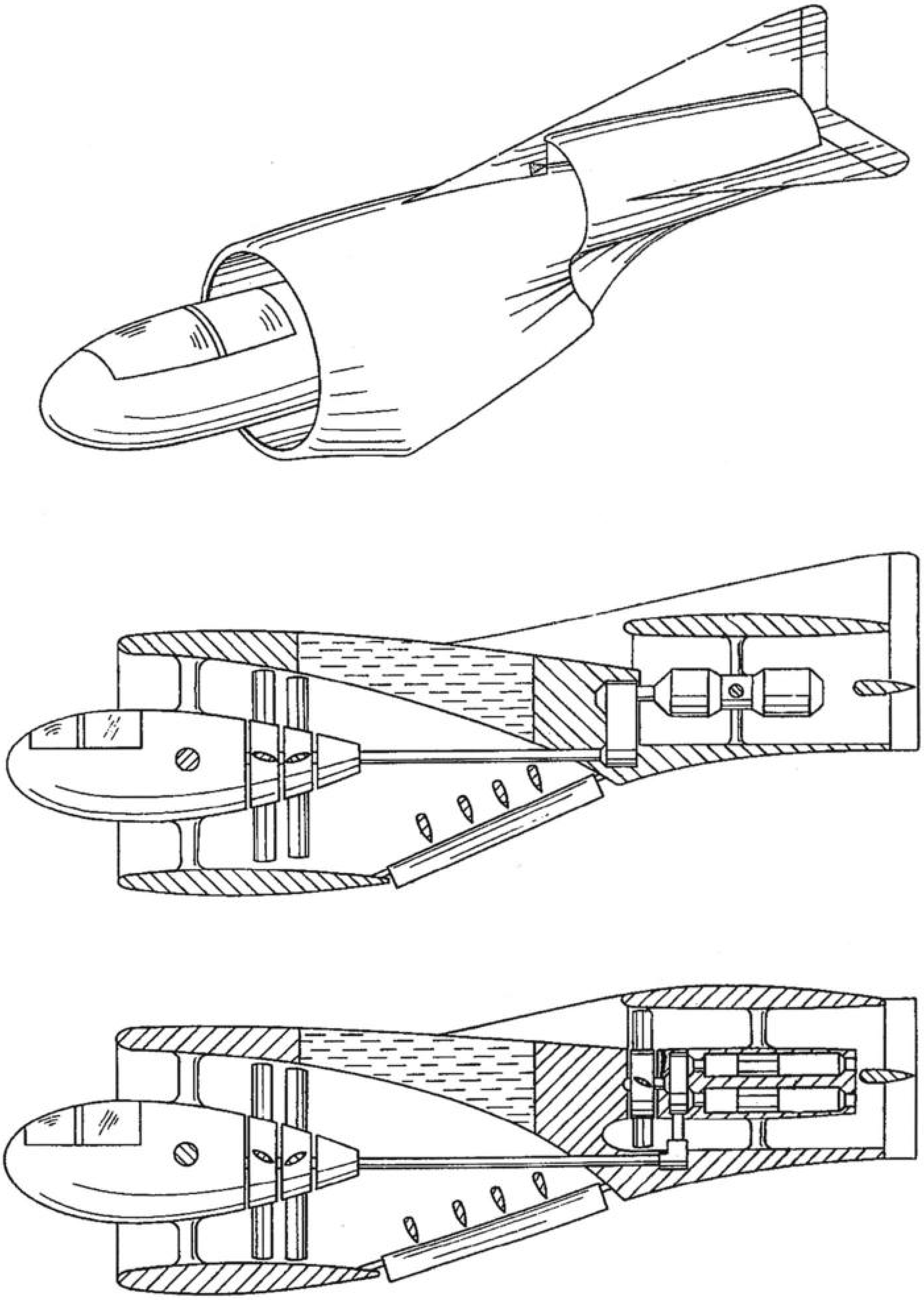
In 1944, Heinkel engineers used Herrmann's research to produce an annular wing ducted-fan VTOL interceptor concept called the Wespe (Wasp). The torpedo-shaped Wespe was a tail-sitter, supported on the ground by three fins with nacelles containing struts and wheels that would be shrouded during flight. A Daimler-Benz DB-109-021 turboprop (also referred to as the HeS 021), developed from the Heinkel HeS 011 turbojet, provided power for a six-bladed propeller contained inside the annular wing, with exhaust from the engine exiting at the tail. This compact aircraft had a proposed overall length of approximately 20ft (6.1m), a span of 16ft (4.9m), an anticipated take-off weight of 4,696 lb (2,130kg) and a maximum speed of 500mph (805km/h) in level flight. The Wespe would be flown with the pilot in a prone position and was armed with two 30mm MK 108 cannons positioned on either side of the cockpit.

This concept never progressed beyond the drawing board and on 25th February 1945 it was superseded by another design called the Lerche (Lark). Although similar in appearance and carrying the same armament, this larger 30ft (9.14m)-long proposal was powered by two separate Daimler Benz DB605D piston engines driving contra-rotating propellers within the annular wing. The estimated performance was similar to the Wespe but range, reliability and production costs were expected to be significantly better. Initial studies were completed at Vienna on 8th March 1945 as the war in Europe drew to an end.

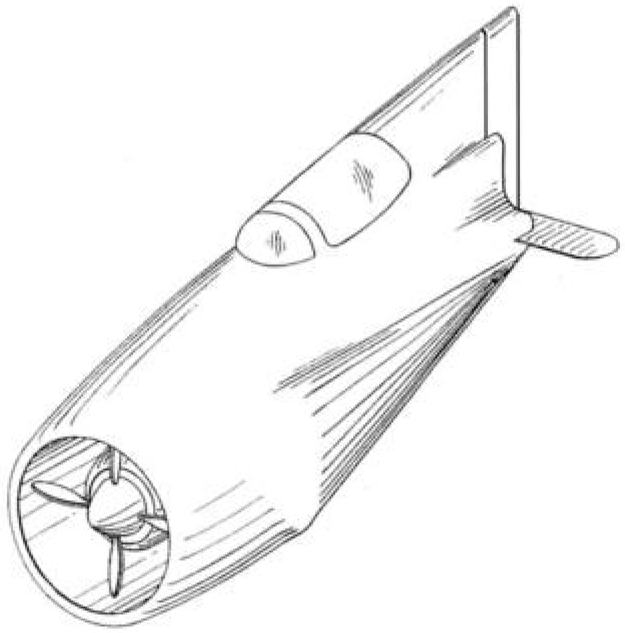
The annular wing ducted-fan concept was also explored in some detail by Dr Alexander Lippisch, who recognised the possibilities offered by this configuration. During his time with the Collins Radio Company in the 1950s, Lippisch supervised the construction of several ducted-fan models and one full-size mock-up. He filed a series of patents during this period and these designs were usually referred to as 'Fluid Sustained and Fluid Supported Aircraft'. In 1967 the West German Dornier Aviation Company took over the development of Lippisch's Aerodyne, hoping to utilise the concept for an unmanned drone. This project led to the construction of a vehicle known as the E1, which was successfully test flown in late 1972 although nothing came of the project.

Zborowski's team had followed a broadly similar path to Lippisch, working on a series of ducted fan designs that were identified by the names of beetles. Their proposals ranged from the Hannerton (Cockchafer Beetle), which was a single-seat design propelled by two enclosed contra-rotating propellers, to the much larger Lucane (Stag Beetle) VTOL light transport aircraft with swivelling ducted fan propulsion. However, they were primarily interested in the military market and the bureau focused their attention on proposals like the Bruche (Beetle), which was a very compact VTOL supersonic ground-attack aircraft with many features that would find their way into the later SNECMA C.450.

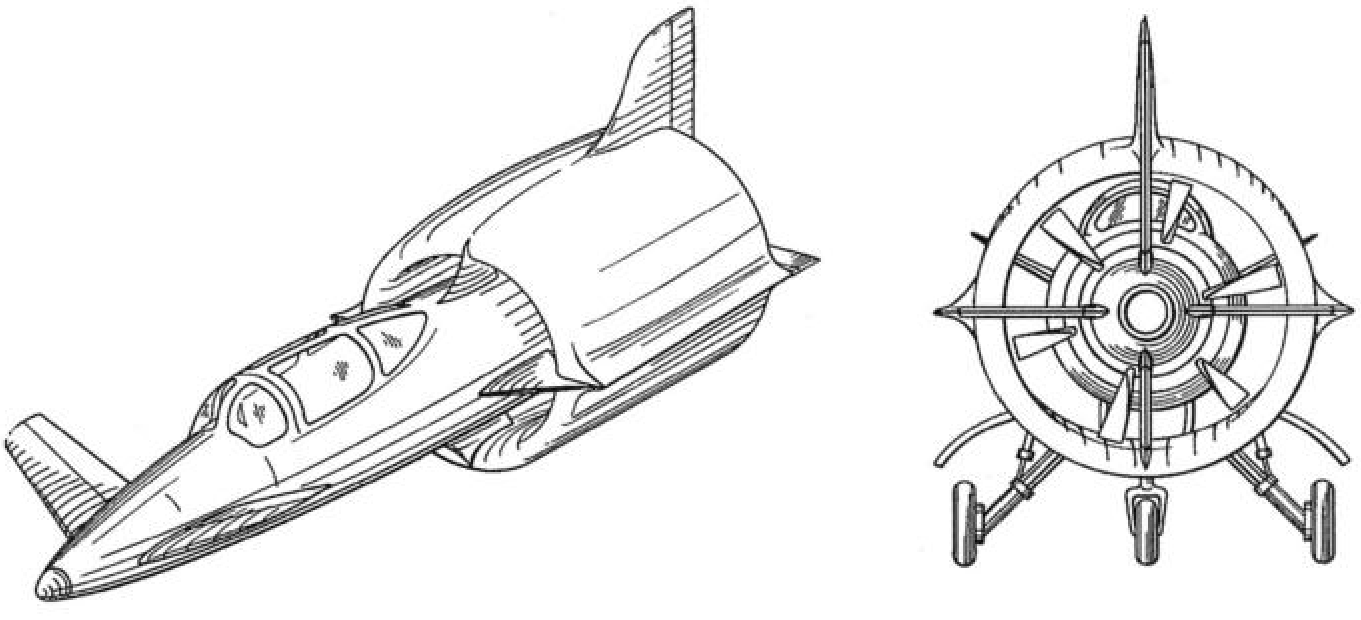
At the beginning of the 1950s Zborowski travelled to Paris, where he approached senior management at the nationally owned French engine manufacturer Société Nationale d'Etude et Construction de Moteurs d'Aviation (SNECMA) with VTOL proposals put together by his team. SNECMA's executives immediately recognised the potential of BTZ's preliminary studies and agreed to fund further development. Zborowski then opened an office at Brunoy in France using the full name Société Anonyme Bureau Tech-



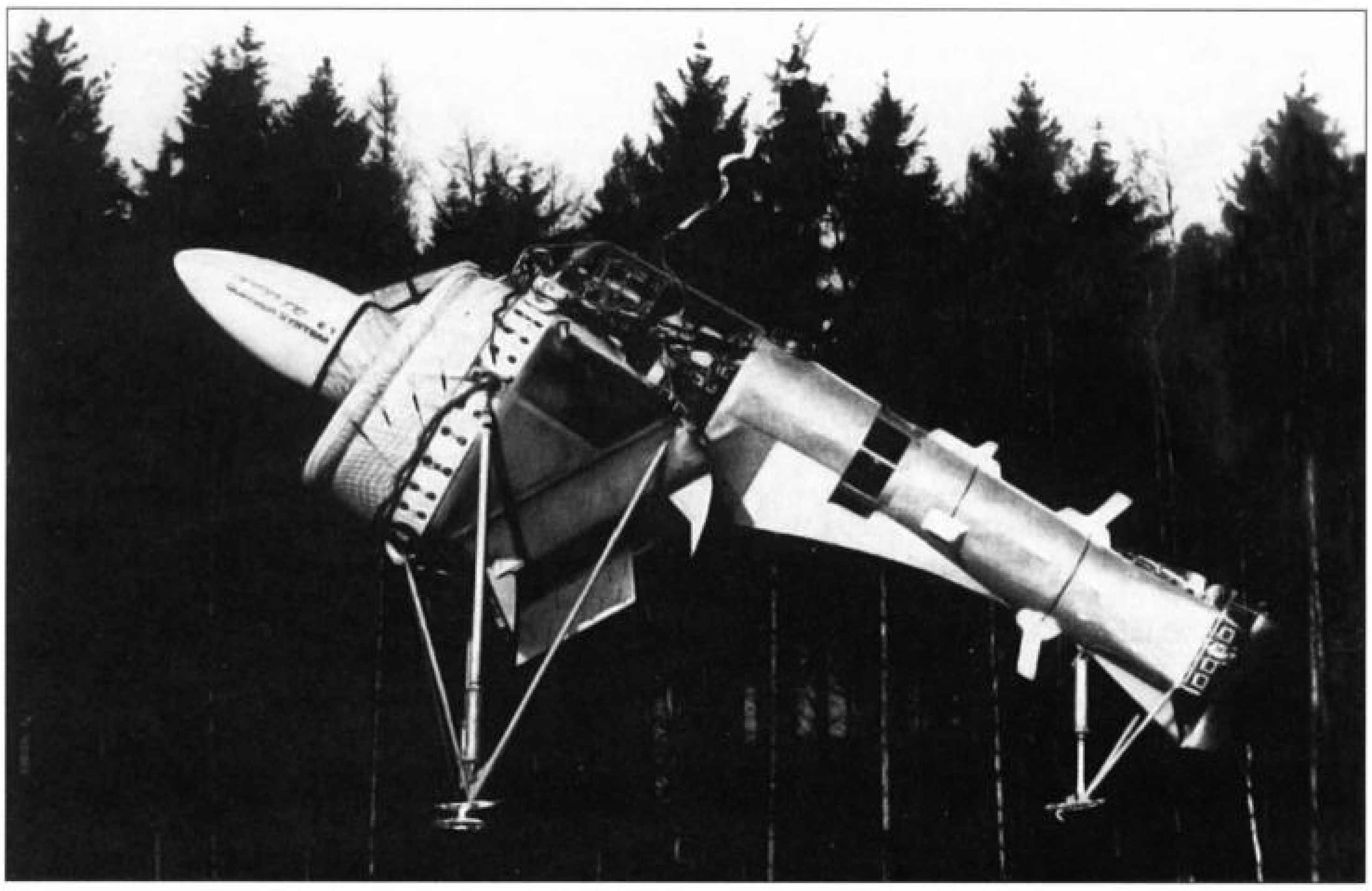
Right: **Lippisch design for ducted fan annular-winged aircraft.** US Patent Office

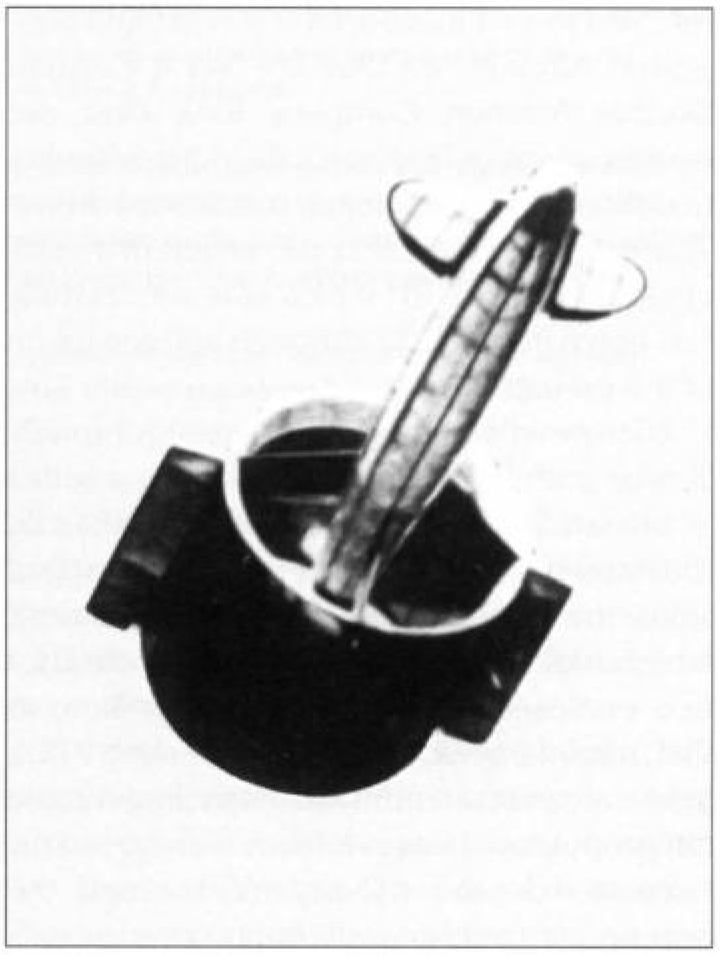


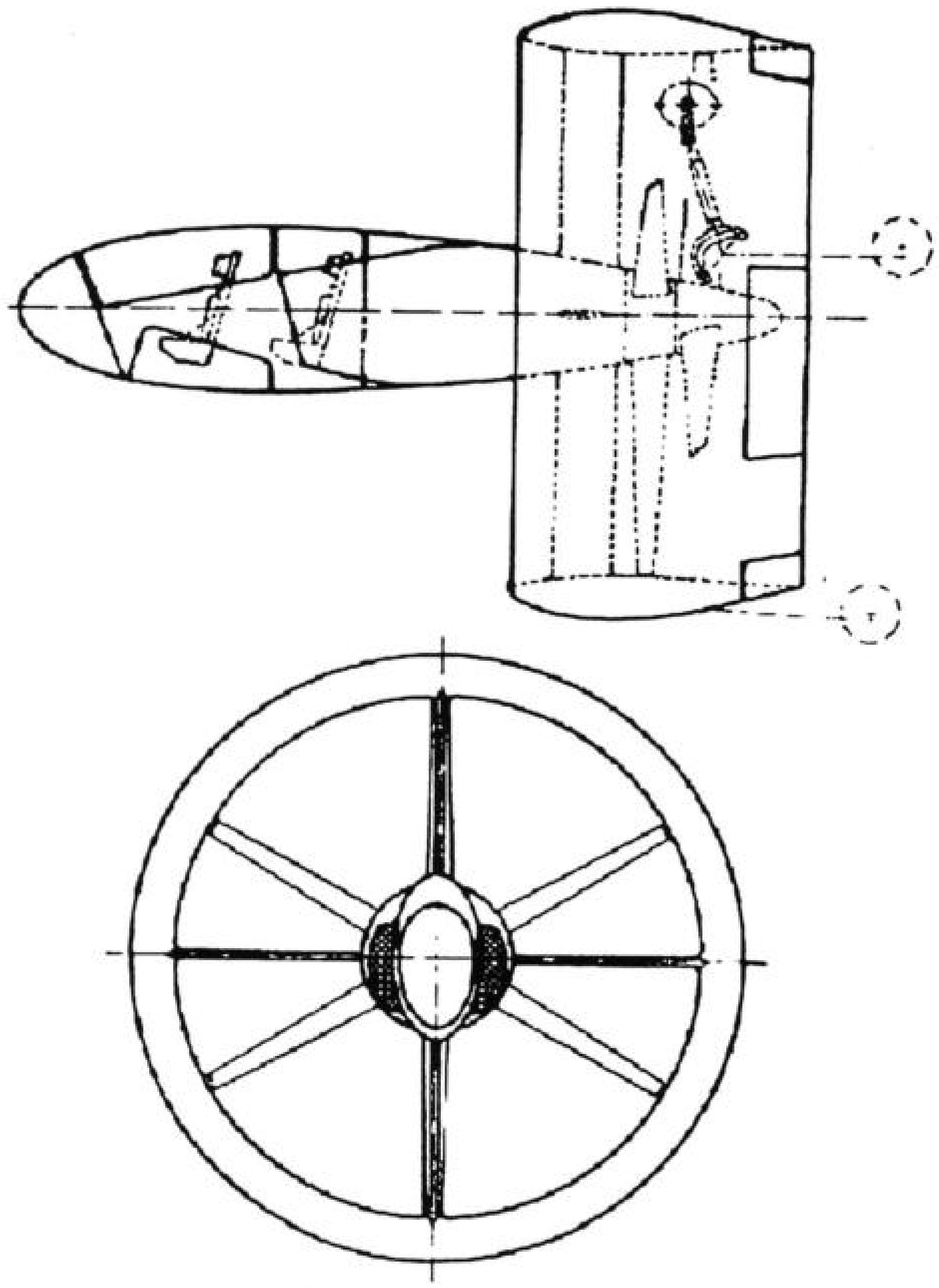
Below: **Early Lippisch design for ducted fan, fluid supported aircraft.** US Patent Office

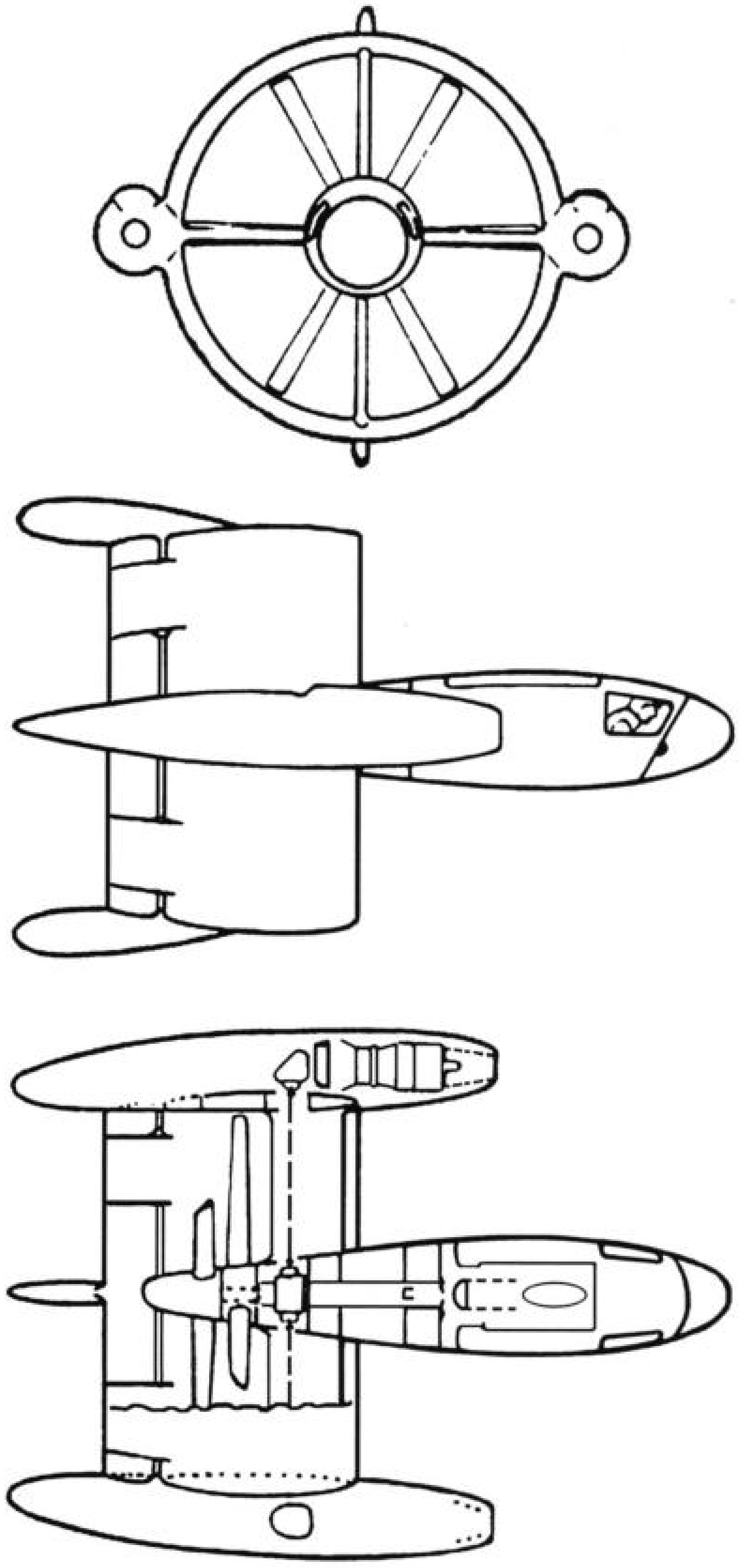


Below right: **Lippisch design for ducted fan annular-winged aircraft.** Bill Rose







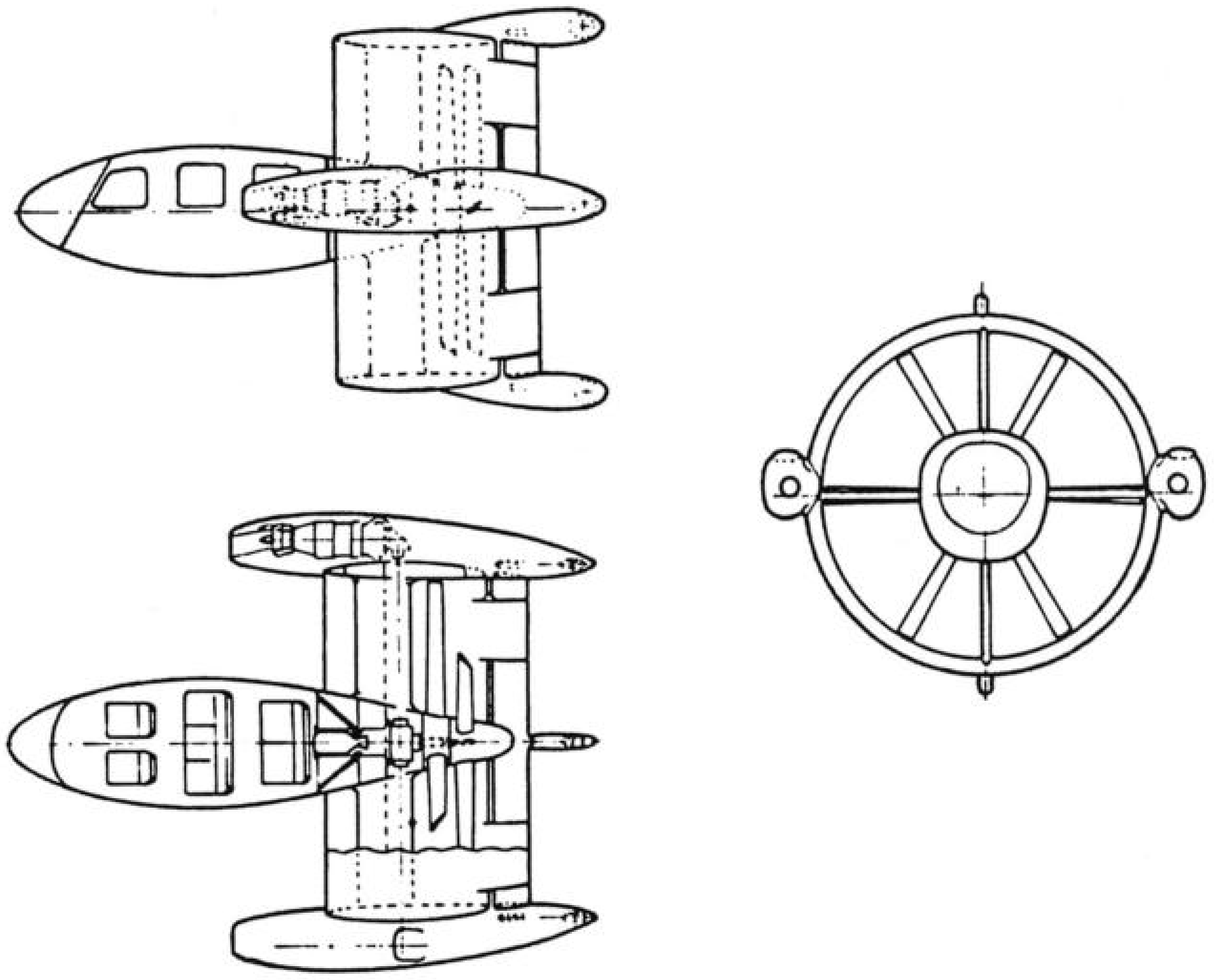


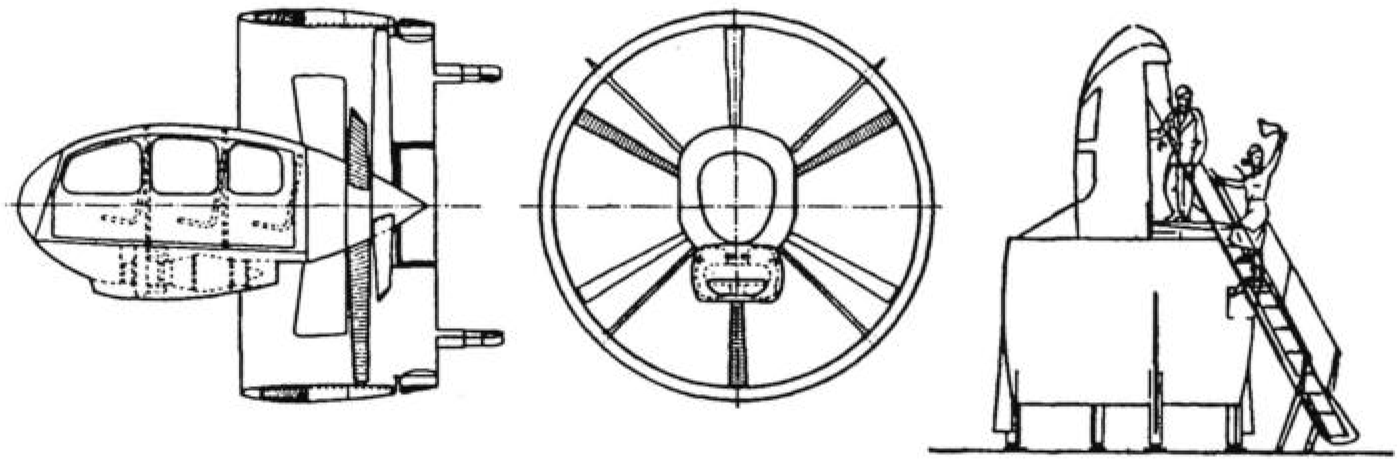
Top left: **Lippisch designed Aerodyne built by the Dornier Aviation Company in 1967 as the test bed for possible unmanned drones.** Dornier Aviation

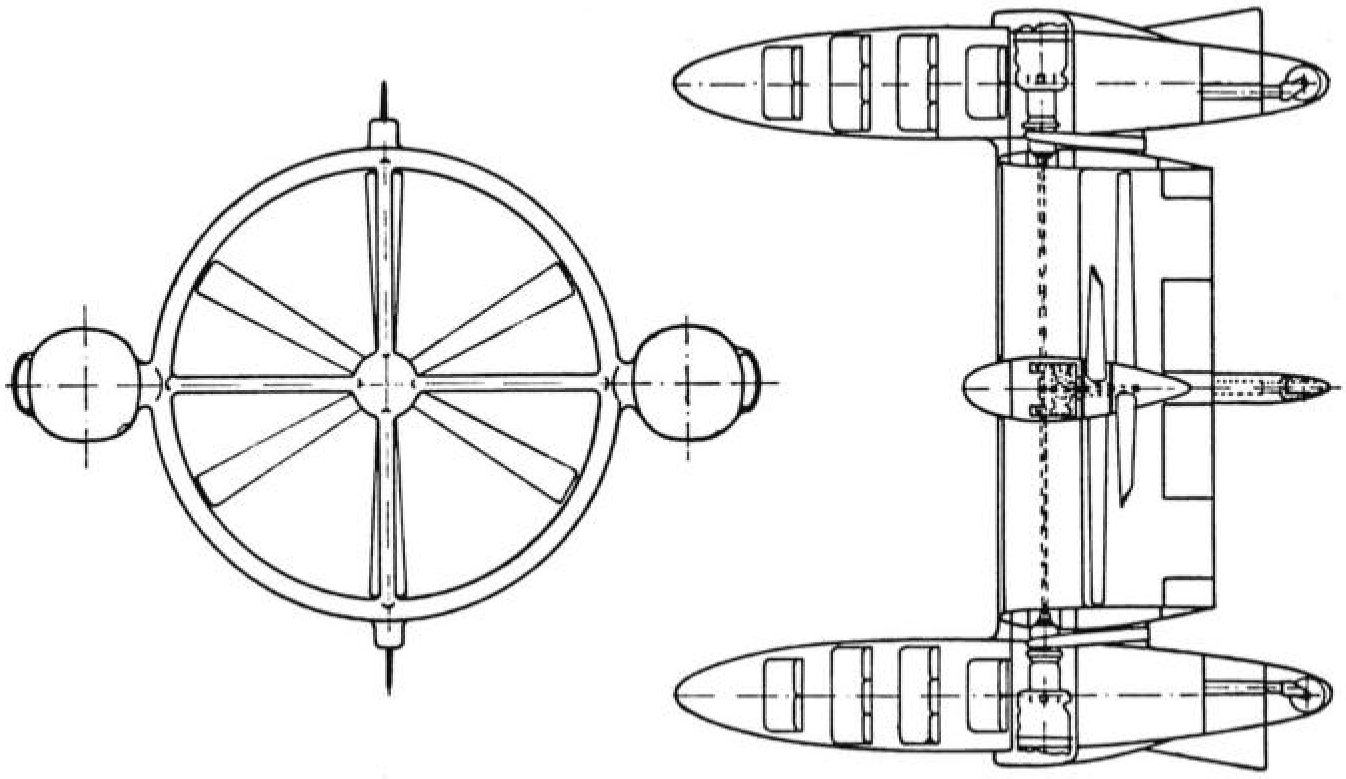
Top right: **Lippisch Aerodyne experimental model.** Collins Radio Company

Above: **BTZ Scarabee ducted fan annular-winged utility aircraft concept.** via Bill Rose

Right: **BTZ Hanneton IS/II design for single-seat ducted fan aircraft with contra-rotating propellers driven by two gas turbines in nacelles.** via Bill Rose







Top to bottom:

BTZ Hanneton IV design for ducted fan aircraft with contra-rotating propellers driven by two gas turbines in nacelles. via Bill Rose

BTZ Hanneton III design for ducted fan utility aircraft with contra-rotating propellers driven by gas turbines below cabin. via Bill Rose

BTZ Hanneton 20C design study for twin-fuselage single ducted fan aircraft with contra-rotating propellers driven by two gas turbines in nacelles. via Bill Rose

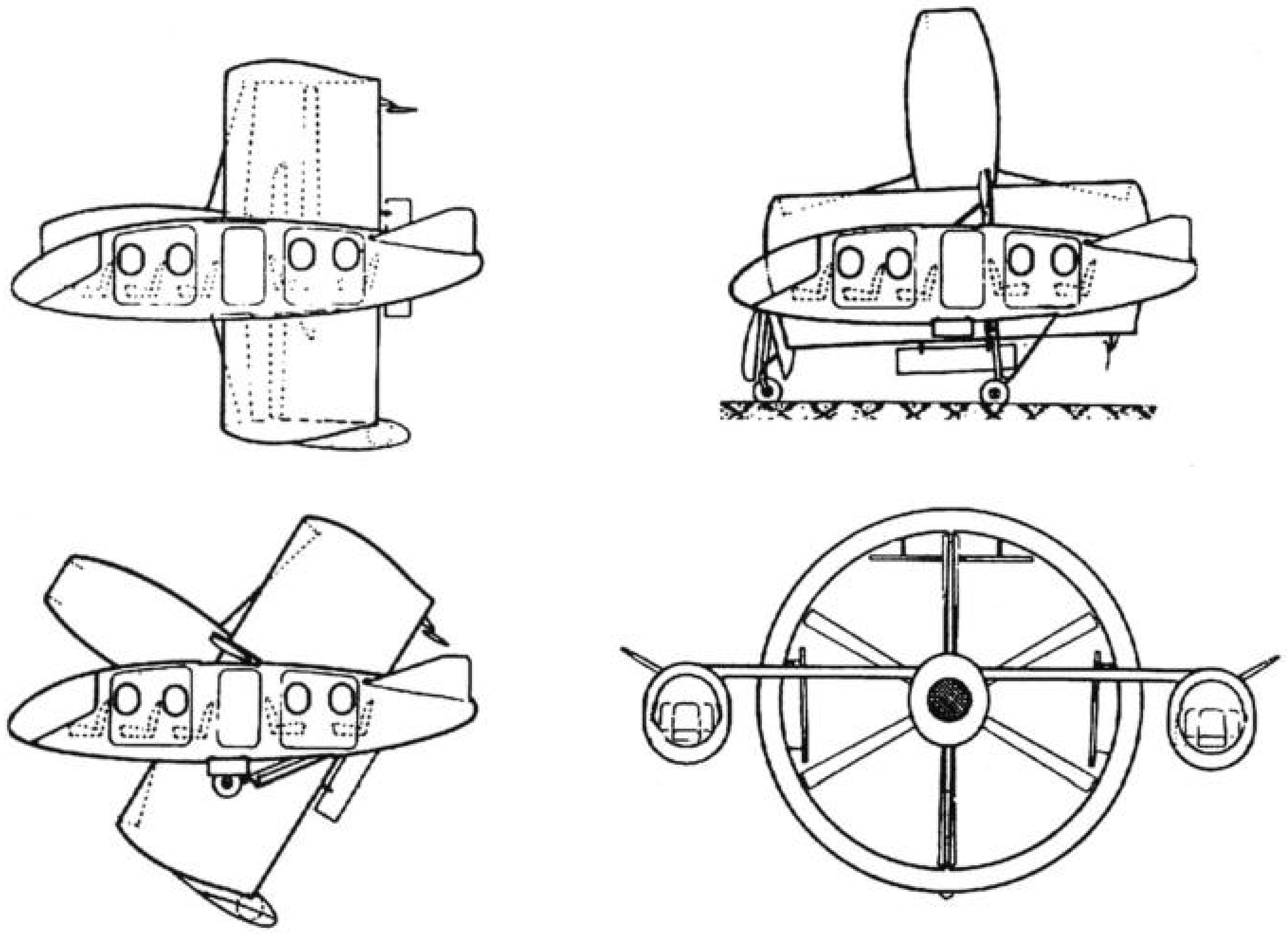
nique Zborowski for his consultancy. As part of the ongoing arrangement it was agreed that SNECMA would purchase the patents for those designs provided to them and the transfer was formalised in 1951.

The SNECMA VTOL fighter project started in 1952 with tests to determine if it was possible to control the direction of flight by blowing compressed air into an engine's jet stream. A modified de Havilland Vampire jet was used for these experiments and by the following year this arrangement had been fully integrated with a flight control system. In 1954 the next stage of testing began to establish remote control use of a joystick, which operated an Ecrevisse pulsejet mounted in a vertical test rig. This phase of intense research and development continued for another two years and a team of 150 personnel worked on the project, managed by German design engineer Gerhard Eggers.

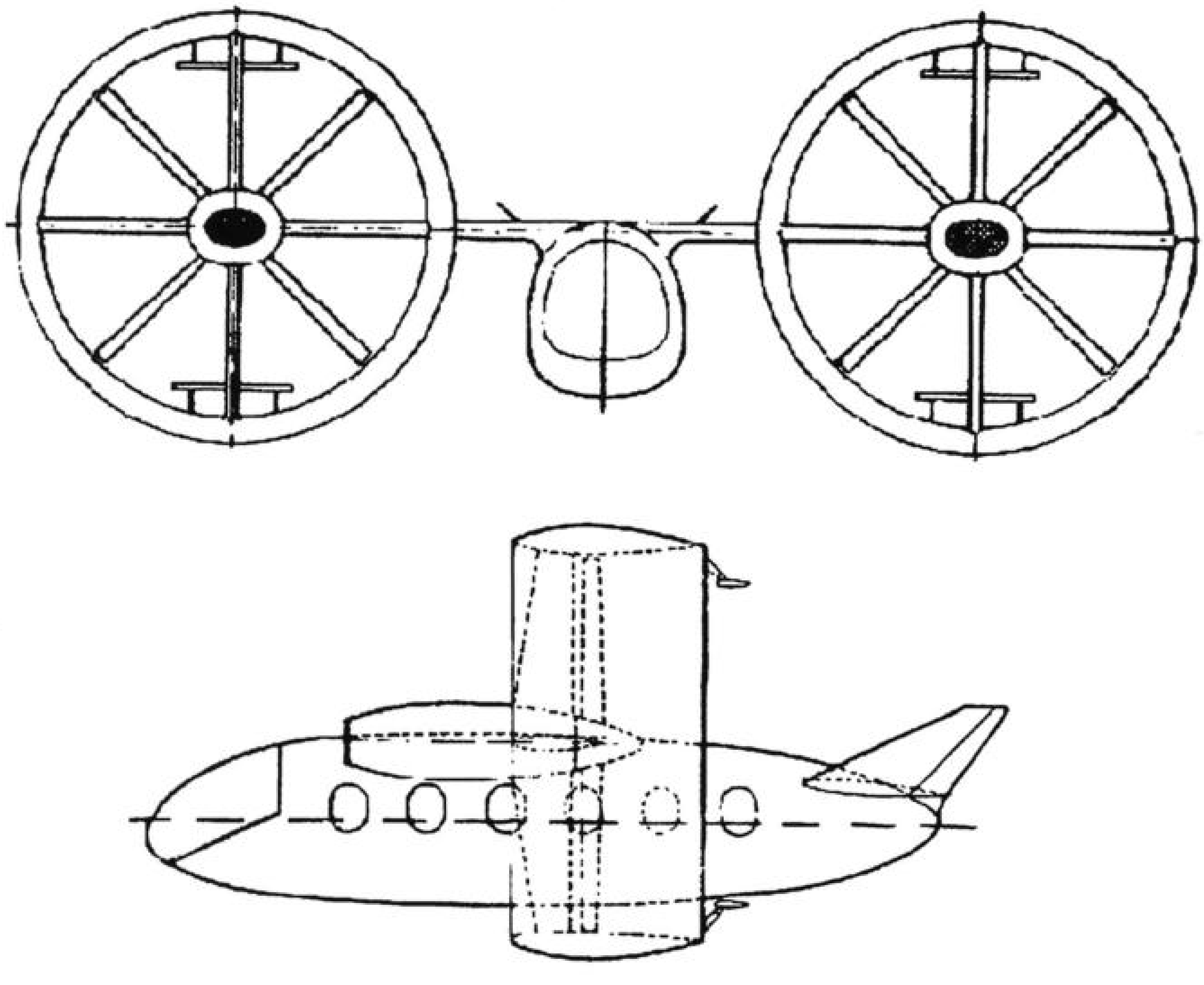
This work led to construction of a proof-of-concept prototype known as ATAR CP.400-P1 (also sometimes called the ATAR Volant – Flying ATAR). This was little more than an enclosed turbojet and fuel tank supported by four legs (fitted with castor wheels) extending from the base. Suspended from a large gantry, this strange-looking contraption used a 6,400 lb (28.4kN) thrust ATAR D jet engine and made the first of 250 flights under remote control during October 1955.

Atelier Technique Aeronautique Rickenbach (ATAR) engines had evolved directly from BMW's wartime research. In May 1945 the ATAR Company was established at Rickenbach in Switzerland by BMW's chief designer Dr Hermann Oestrich, who had fled across the border with other BMW scientists and engineers in the last days of World War Two. ATAR jet engines built by SNECMA were to become a key part of the post-war French military aircraft industry.

During 1955 West Germany joined NATO and was now working hard to rebuild its military capability. With the Lockheed F-104 Starfighter on order as the Luftwaffe's next



BTZ Lucane design for twin-fuselage light transport aircraft with a rotating annular wing/ducted fan enclosing contra-rotating propellers driven by central powerplant. via Bill Rose



An alternative design by BTZ for a Lucane light transport aircraft using two rotating ducted fans for lift and level flight. via Bill Rose

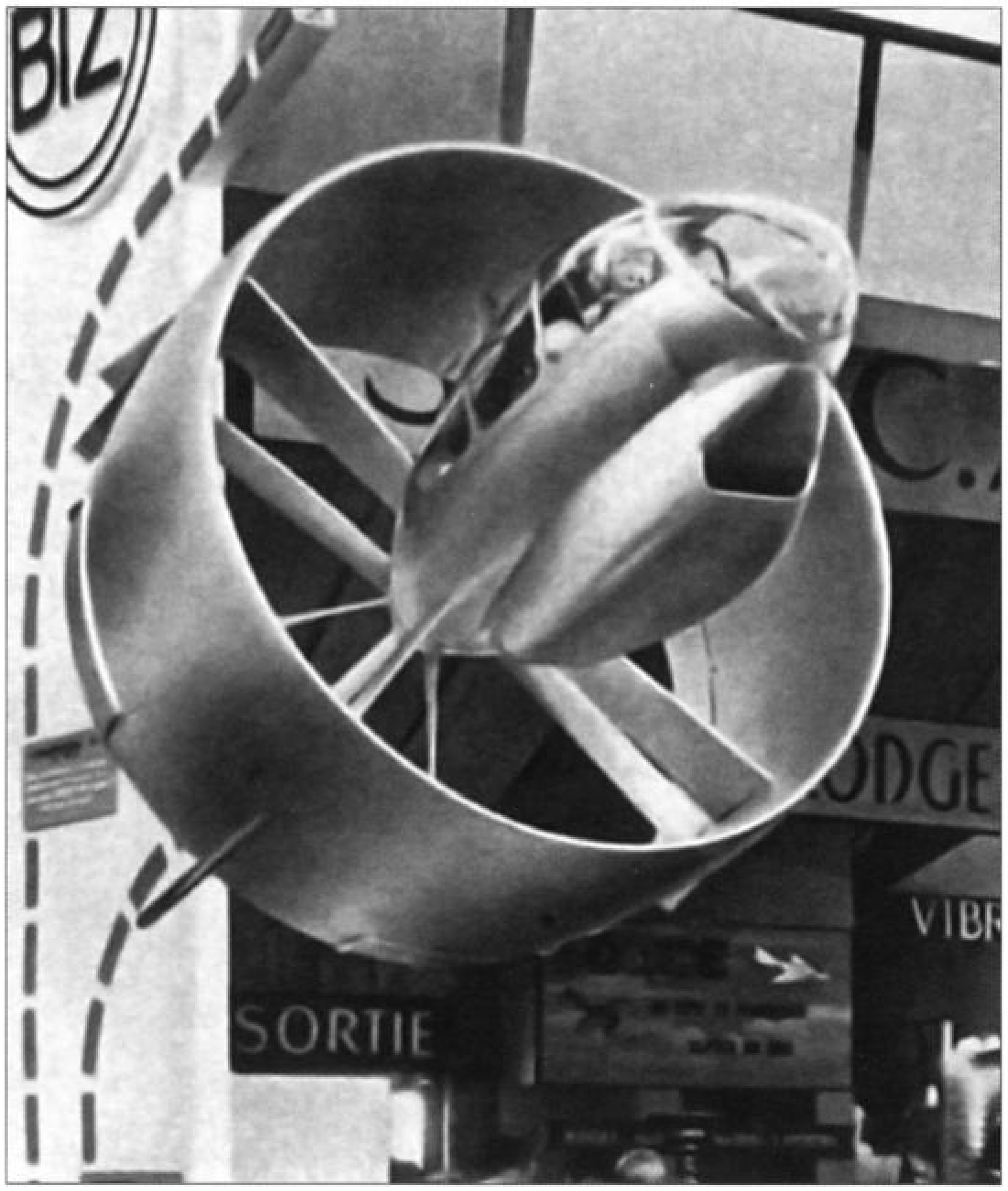
major combat aircraft, there were already studies taking place to find a follow-on replacement, which would ideally be an indigenous product. The Luftwaffe favoured a V/STOL interceptor that was able to offset the vulnerability of front line airfields to Warsaw Pact forces. Nevertheless, the German aircraft industry was still recovering from World War Two. Many of the country's best engineers and scientists had been lost to overseas contractors and manufacturers had been forced to diversify into less demanding fields. The Luftwaffe requirement for a next-generation combat aircraft was designated VJ 101 – the VJ denoting Vertikal Jäger (VTOL Fighter). It called for an aircraft with Mach 2.5 performance, a ceiling of 72,000ft (22,000m) and an operation range of 310 miles (500km).

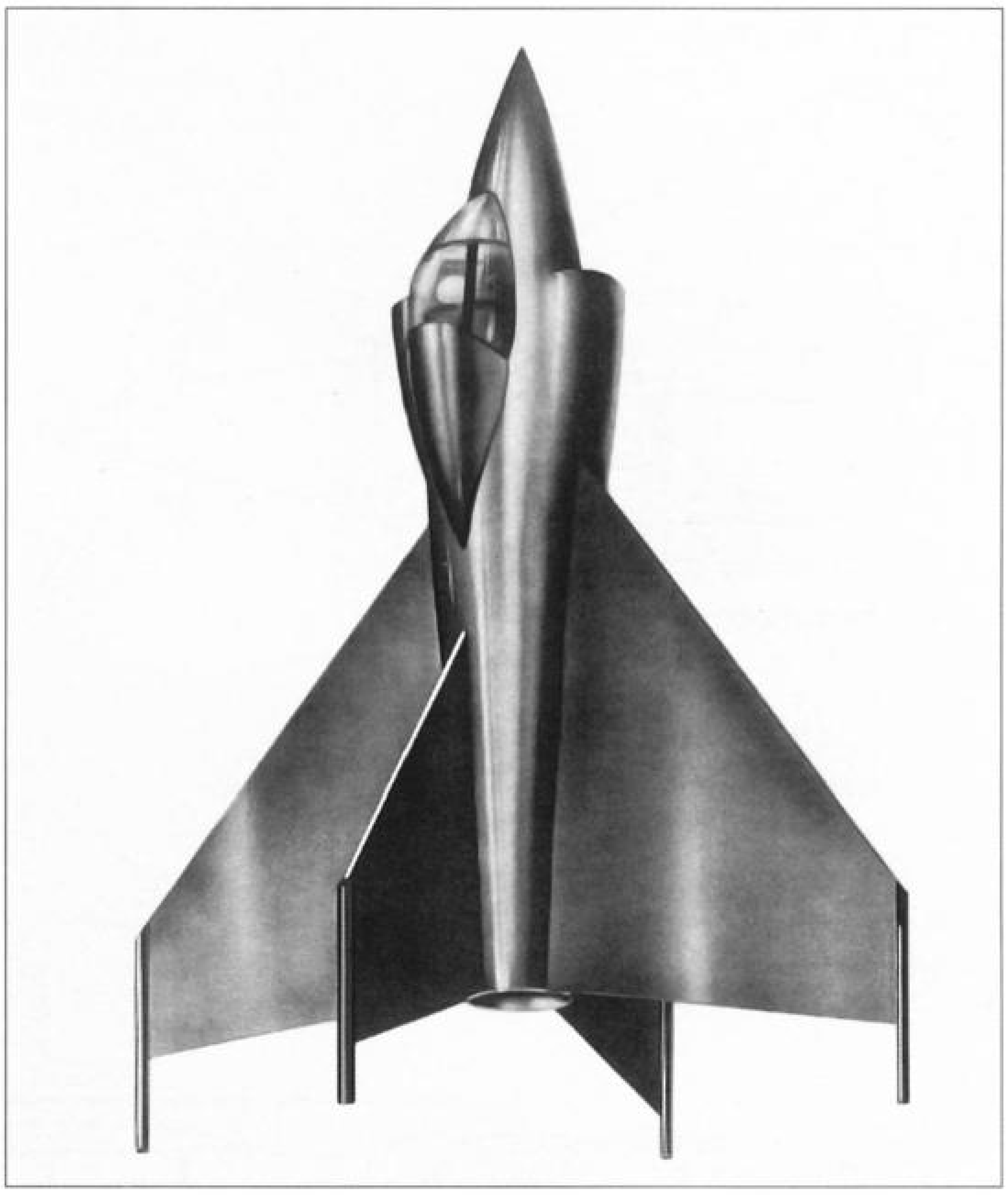
With encouraging work being undertaken by SNECMA, the West German authorities agreed to provide additional funding to the project. Four West German aviation companies also became involved and each began studies of VTOL fighters that drew on the research and development taking place in France. By early 1957 significant funding was forthcoming from the West German Government and several contractors were actively studying adaptations of the SNECMA annular-winged designs for Luftwaffe needs. From a resulting design contest, two leading projects emerged – these were the Bolköw P 110.1 and the Heinkel He 231, with the rocket-like Heinkel proposal taking first place.

Now that the West German government was providing additional support it was decided to push forward with the SNECMA project with a series of upgrades to the design. On 30th March 1957, the CP.400-P2 made its first tethered flight. This version differed by using a slightly more powerful ATAR DV engine and having a rudimentary cockpit installed on top of the vehicle, which would allow manned untethered flights. A total of 132 gallons (600 litres) of fuel was carried and an automatic stabilisation system was introduced to keep CP.400-P2 upright. With SNECMA's test pilot Auguste Morel at the controls, CP.400-P2 made its first free flight on 14th May 1957.

In 1958 the CP.400-P3 was completed; this differed from the previous test-bed by having a forward-tilting ejector seat and inlets for the jet engine on either side of the cockpit. To establish if there was a possibility of engine flame-out during descent due to problems with the engine inlets, C400-P3 was mounted on railway rolling stock and exhaust tests were conducted along a length of track between Étampes and Pithiviers near Paris. The train was driven backwards at speed to simulate a vertical touch-down, generating many strange rumours about the project and French railways. However, these unorthodox trials were not very successful and further experiments were conducted in the large wind tunnel at Modane, although CP.400-3 never actually flew as a manned testbed.

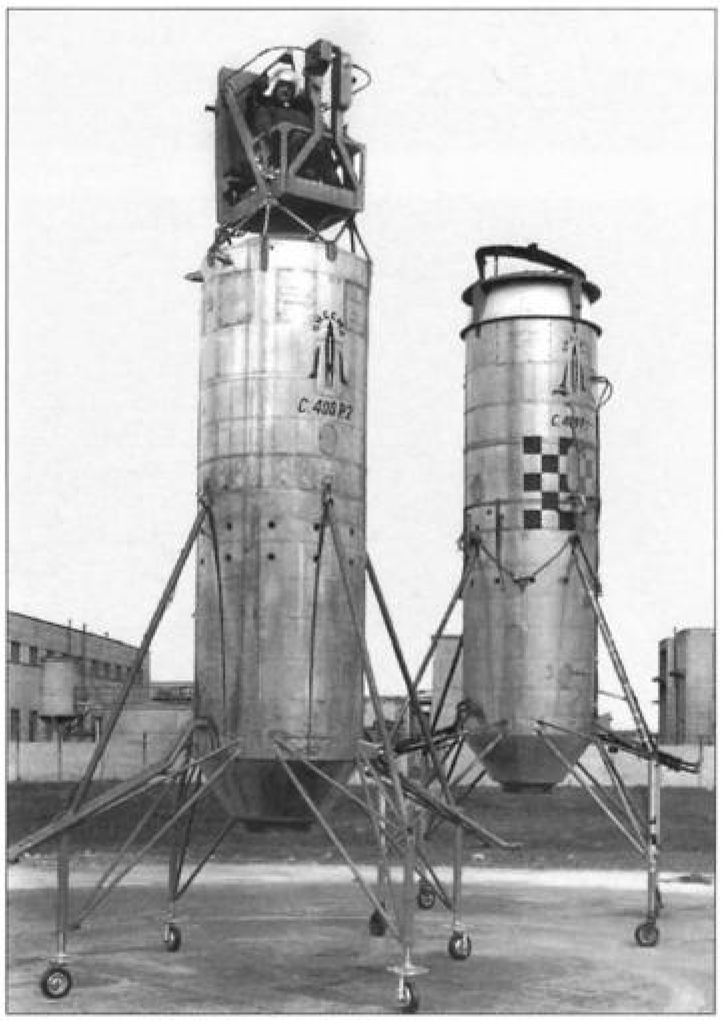
At the same time SNECMA built a full-sized mock-up of a prototype manned VTOL air-





Above: **Model of BTZ Hanneton IIIA ducted fan annular wing light utility aircraft.** via Bill Rose

Above right: **Produced in the early 1950s, this is an early SNECMA design for a VTOL jet fighter, which was clearly influenced by VTOL turboprop projects undertaken by Lockheed and Convair for the US Navy.** SNECMA



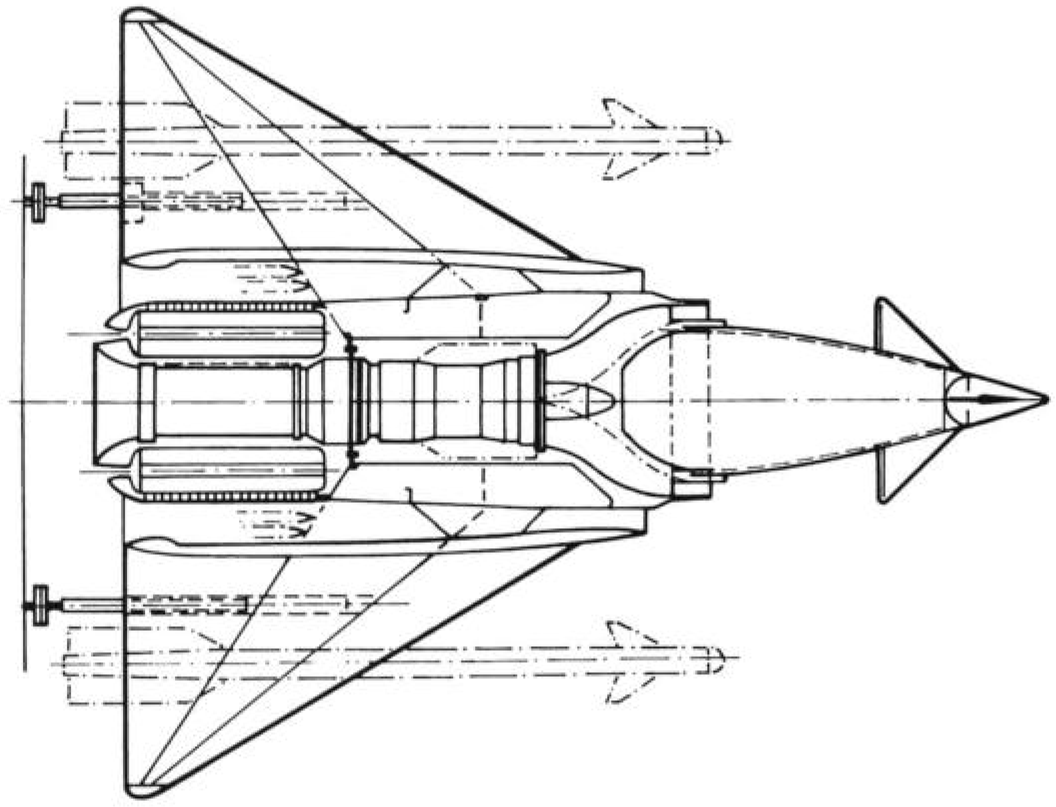
Right: **The SNECMA C.400 P.1 and P.2 (manned) experimental VTOL test vehicles.** SNECMA

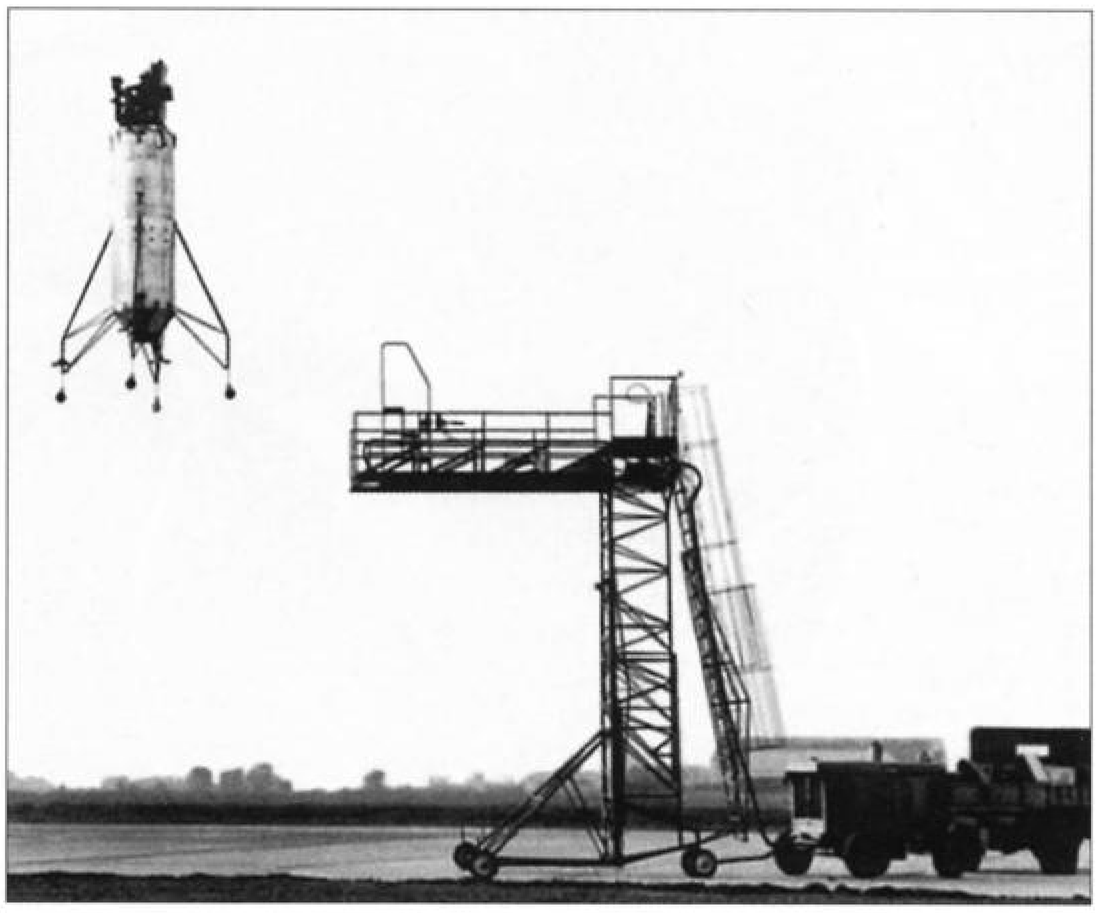
craft and in mid-1958 the company received official approval to proceed, with the airframe being sub-contracted to Nord Aviation (who became Aerospatiale and then EADS). This combined all the features developed during the ATAR Volant programme with the annular wing, which Zborowski had patented and sold to SNECMA. Designated C.450, it was then named Coléoptère, which had started out as a combination of Greek words Koleos for 'sheath' and Pteron for 'wing', but finally became the French word for Flying Beetle.

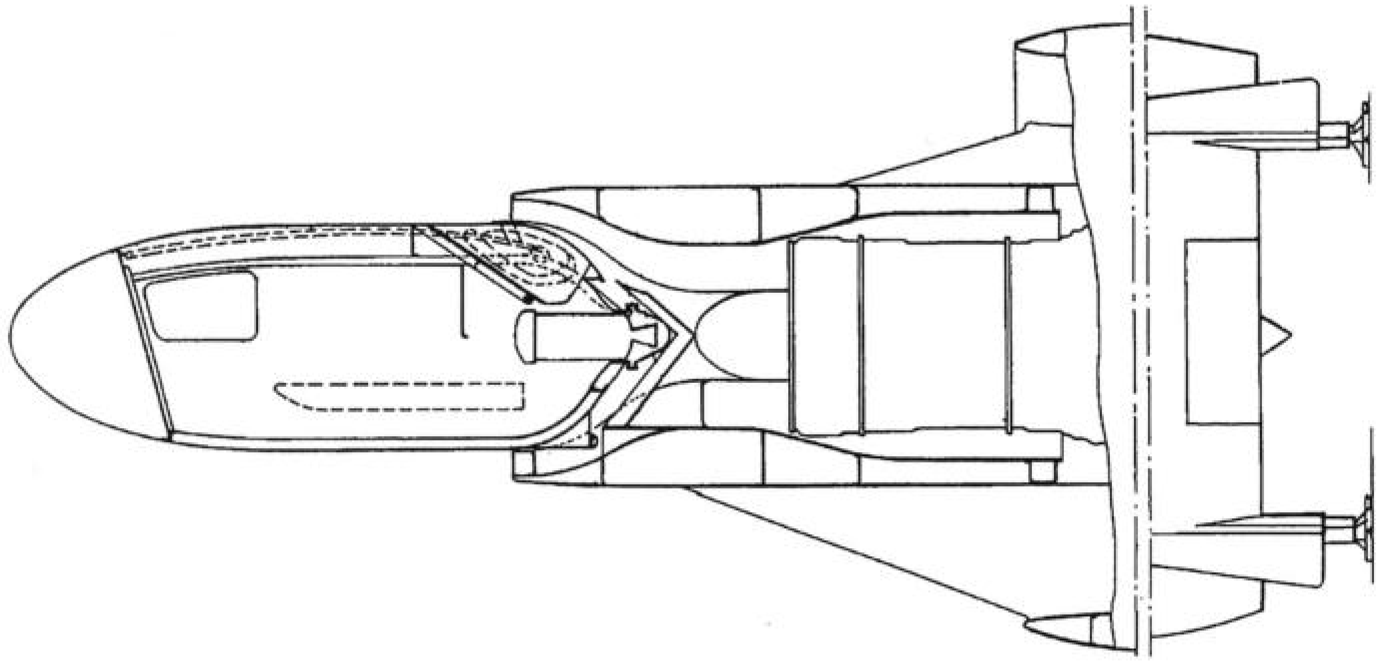
The C.450 airframe was completed at Châtillon in 1958. Its overall dimensions were a length of 26ft 4in (8.03m) and diameter 14ft 9in (4.50m), which provided a wing area of 304.6ft^2 (28.3m^2). The SNECMA engineering team then spent the best part of another year installing the engine and all of the systems. Power was provided by a single Atar 101 E-5V gas turbine delivering 7,700 lb (34.2kN) of static thrust. The aircraft weighed 4,870 lb (2,209kg) empty and had a maximum of weight of 6,613 lb (3,000kg). External details varied slightly and the C.450 was sometimes equipped with a nose probe and later carried the letter Y on the forward fuselage (thought to signify an experimental vehicle). Tilting vanes in the engine's exhaust nozzle provided control during the hover while the small tail fins took over in forward flight. Two extendable strakes were built into the nose, which assisted in the transition to and from the vertical position.

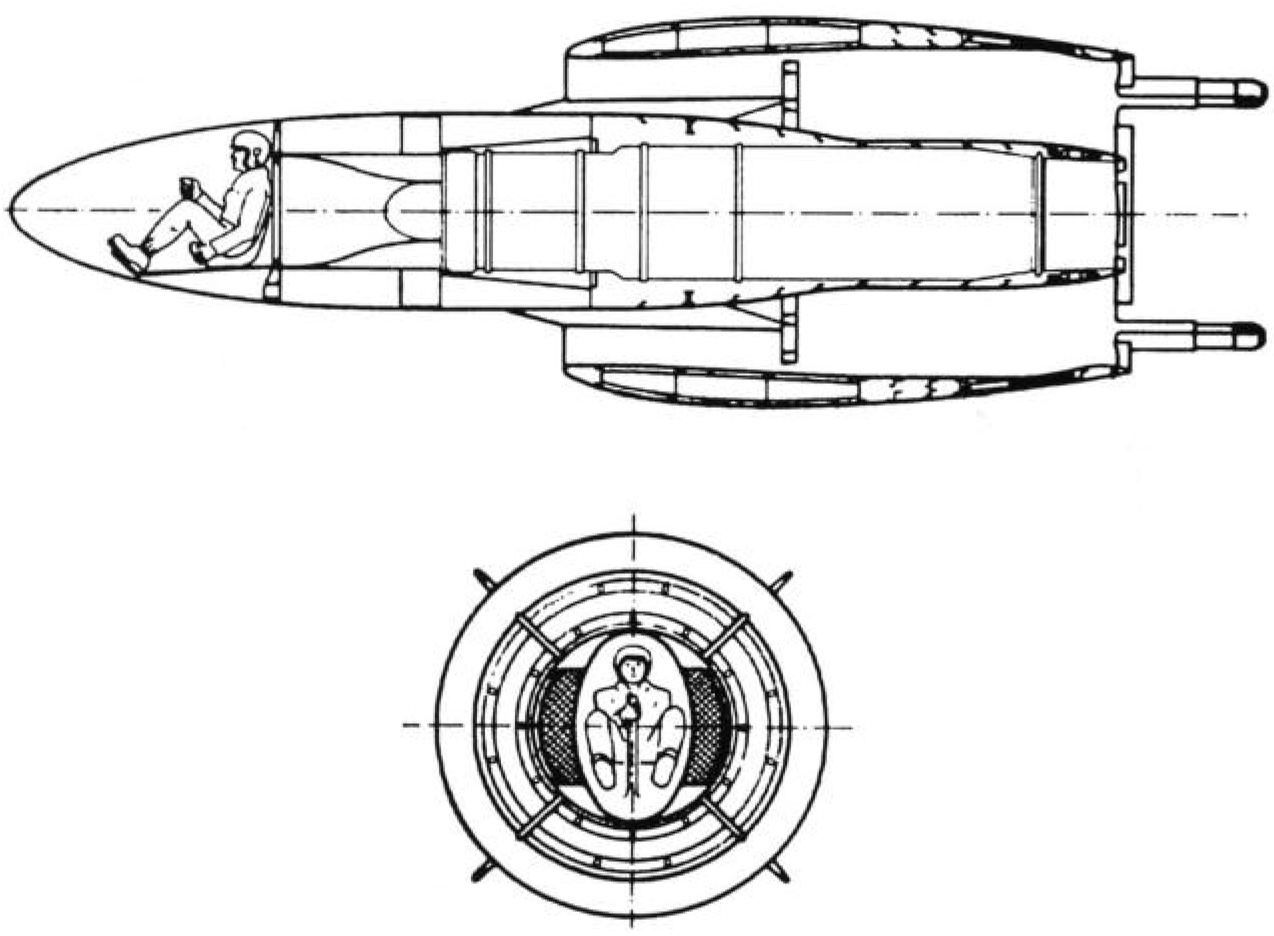
The C.450 made its first tethered hover at Villaroche on 17th April 1959 and undertook its first free hover, which lasted for several minutes, on 3rd May 1959. During the ninth flight on 25th July 1959, the test pilot Auguste Morel climbed to an altitude of 2,000ft (610m). He achieved a transition to about 35° and then returned to the vertical position. But the aircraft suddenly became unstable and Morel couldn't regain control, finally having to eject at 150ft (45m). The C.450 continued to pitch and roll for several seconds before finally crashing into ground. Later, it was suggested that the throttle control had jammed. The C.450 was totally destroyed and Morel was seriously injured. After a meeting of SNECMA executives it was decided to call it a day and abandon any further development of a project that no longer appeared to have any useful military application.

A higher-performance production version of the C.450 had been expected to succeed the C.450 and this VTOL interceptor was to be powered by a SNECMA TF104 (modified Pratt & Whitney TF30) supplemented by ramjet









Above left: **Bolköw P 110.1 VTOL interceptor concept designed as an alternative to the He 231.** via Bill Rose

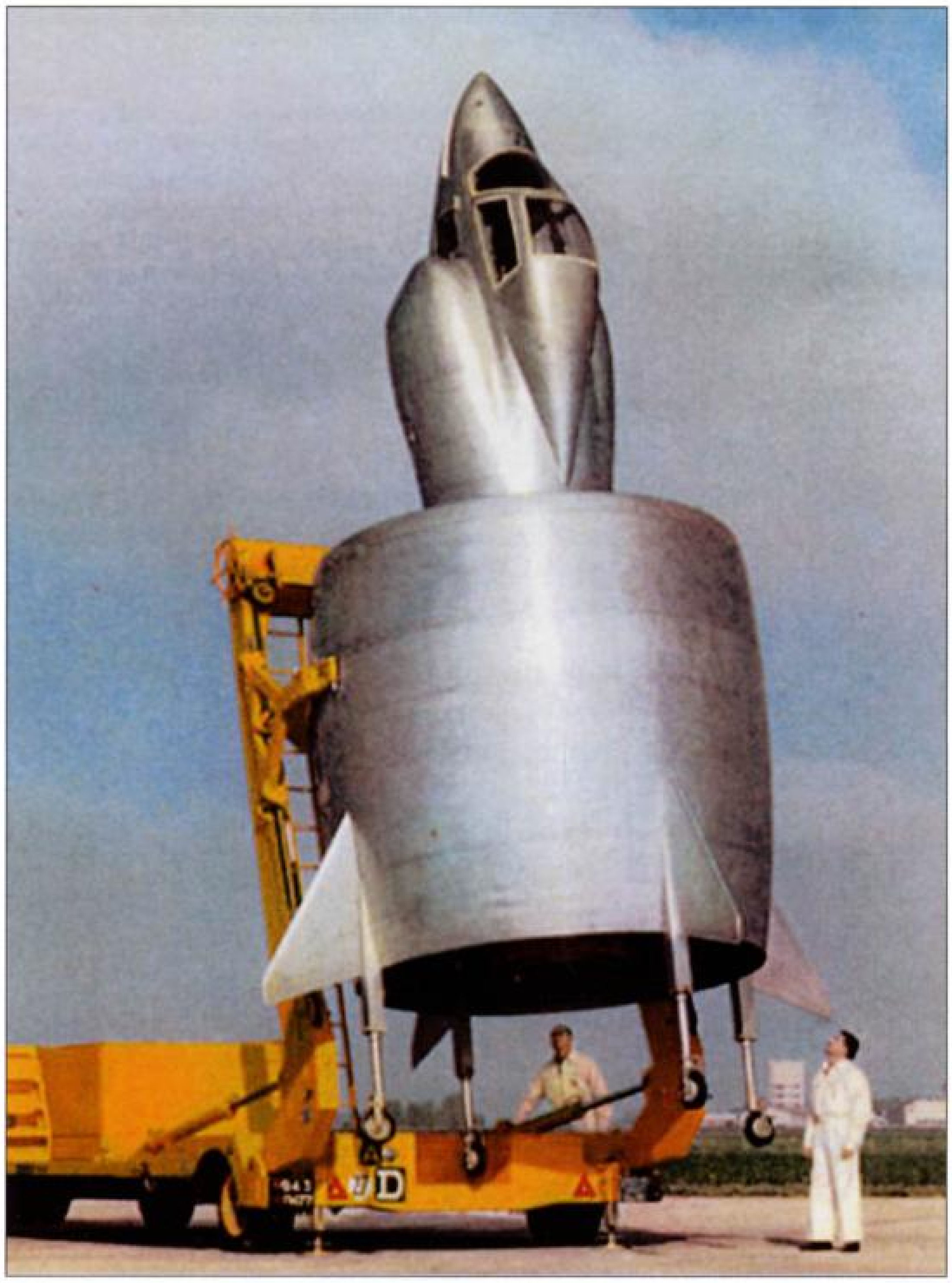
Above right: **The SNECMA C.400 P.2 experimental VTOL test vehicle hovers in mid-air during a test flight near the mobile access gantry.** SNECMA

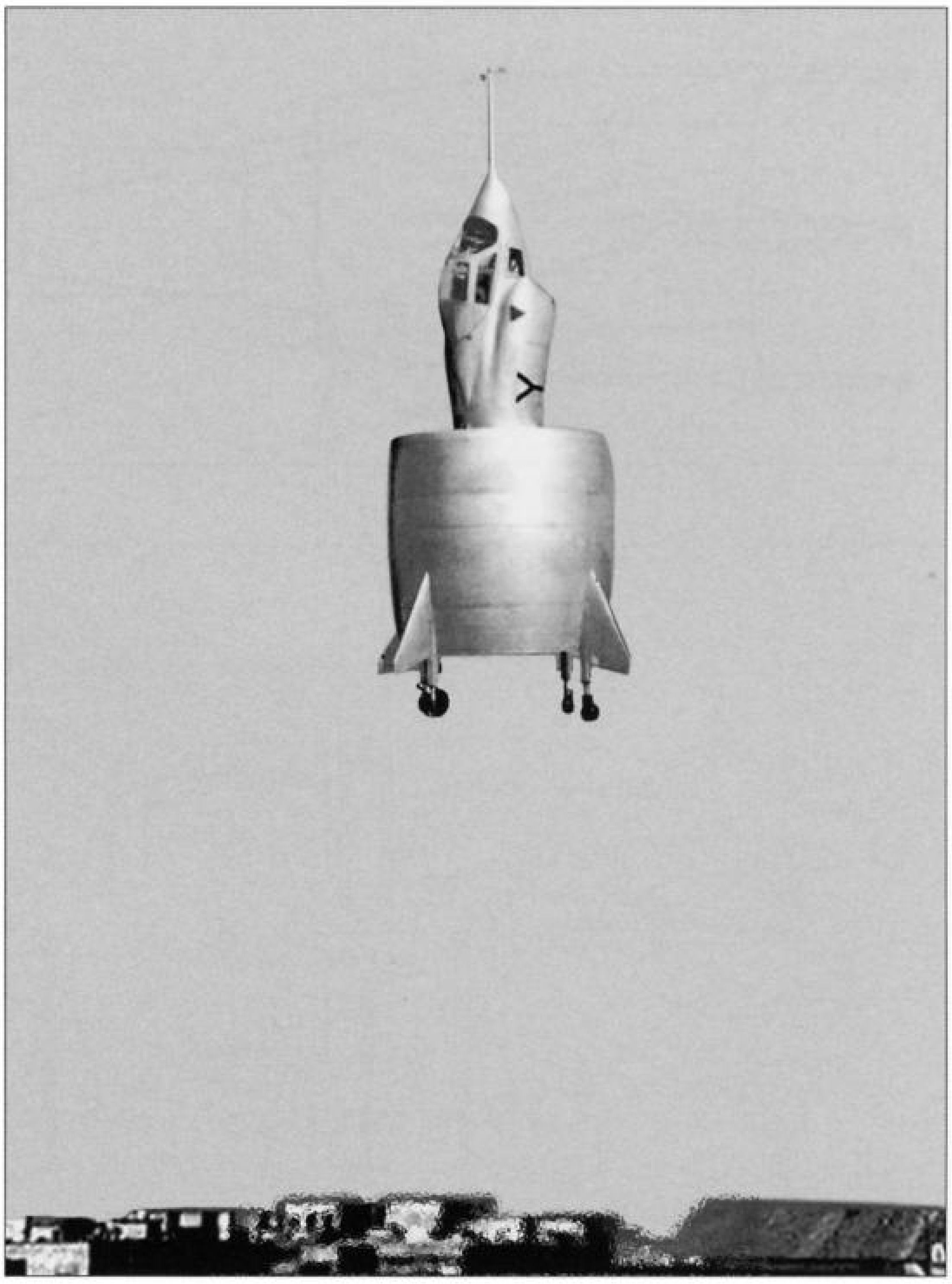
Left: **BTZ early design study for single-seat VTOL fighter aircraft using annular wing and turbojet propulsion. In an emergency, the cockpit capsule can be detached using a rocket escape system.** via Bill Rose

Below left: **A design by BTZ for a single-seat VTOL fighter aircraft designated Bruche, which evolved into the SNECMA C.450.** via Bill Rose

propulsion. The Advanced Coléoptère was given the codename AP507 and it was to have an overall length of 36ft (11.0m) and an annular wing of 8ft 9in (2.7m) diameter. Maximum speed was estimated at Mach 3, with a ceiling of 80,000ft (24,384m), and the armament would be two or possibly four air-to-air missiles mounted outside the wing.

In the meantime BTZ had been working with Heinkel engineers on the He 231 design for West Germany's Luftwaffe, which shared similarities with the AP507 but looked more like a comic-strip spaceship with four large triangular wings that contained the landing gear. Power for the Luftwaffe aircraft was to be provided by a single General Electric J85 gas turbine with reheat and a ramjet option. Performance was expected to be similar to the AP507 and the pilot flew the aircraft in a prone position. Envisaged armament was a single 25mm cannon or two missiles using an alternative wing design. It is not known how far the engineering studies progressed but models were wind tunnel tested before the He 231 was abandoned.

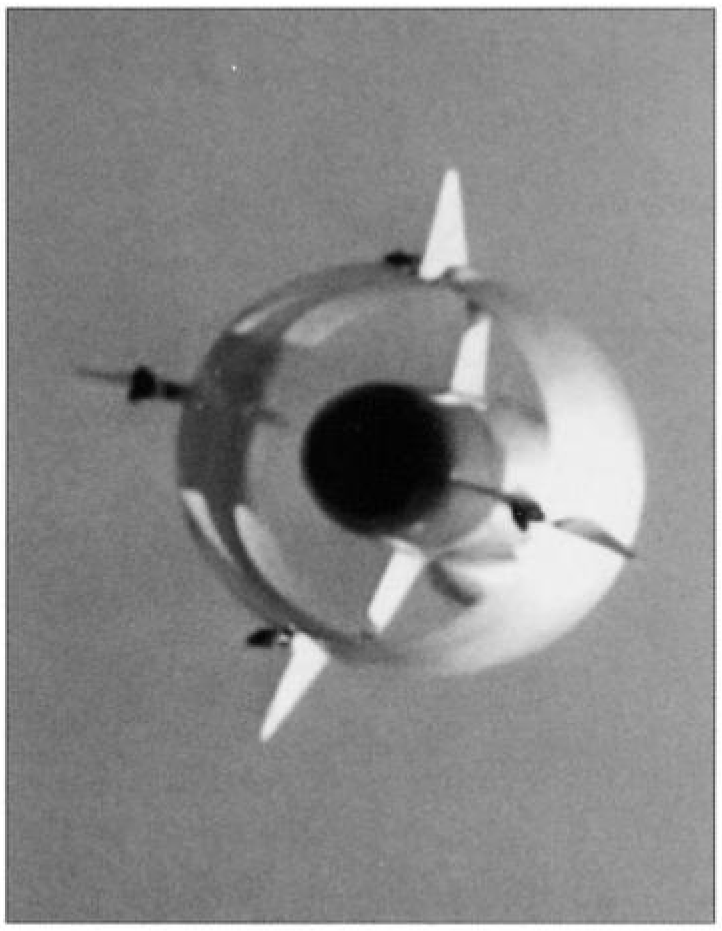




Above left: **The SNECMA C.450 Coléoptère (Flying Beetle) experimental VTOL aircraft is lowered into an upright position from its transport vehicle.** SNECMA

Above right: **The SNECMA C.450 Coléoptère experimental VTOL aircraft hovers in mid-air during a test flight.** SNECMA

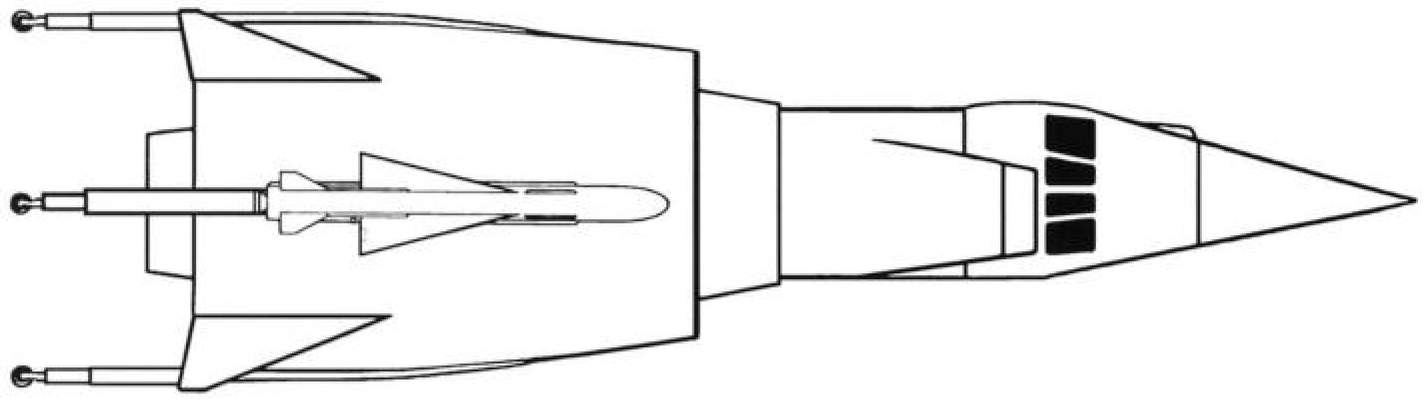
Right: **Telephoto lens image from beneath the SNECMA C.450 Coléoptère VTOL aircraft during a test flight.** SNECMA



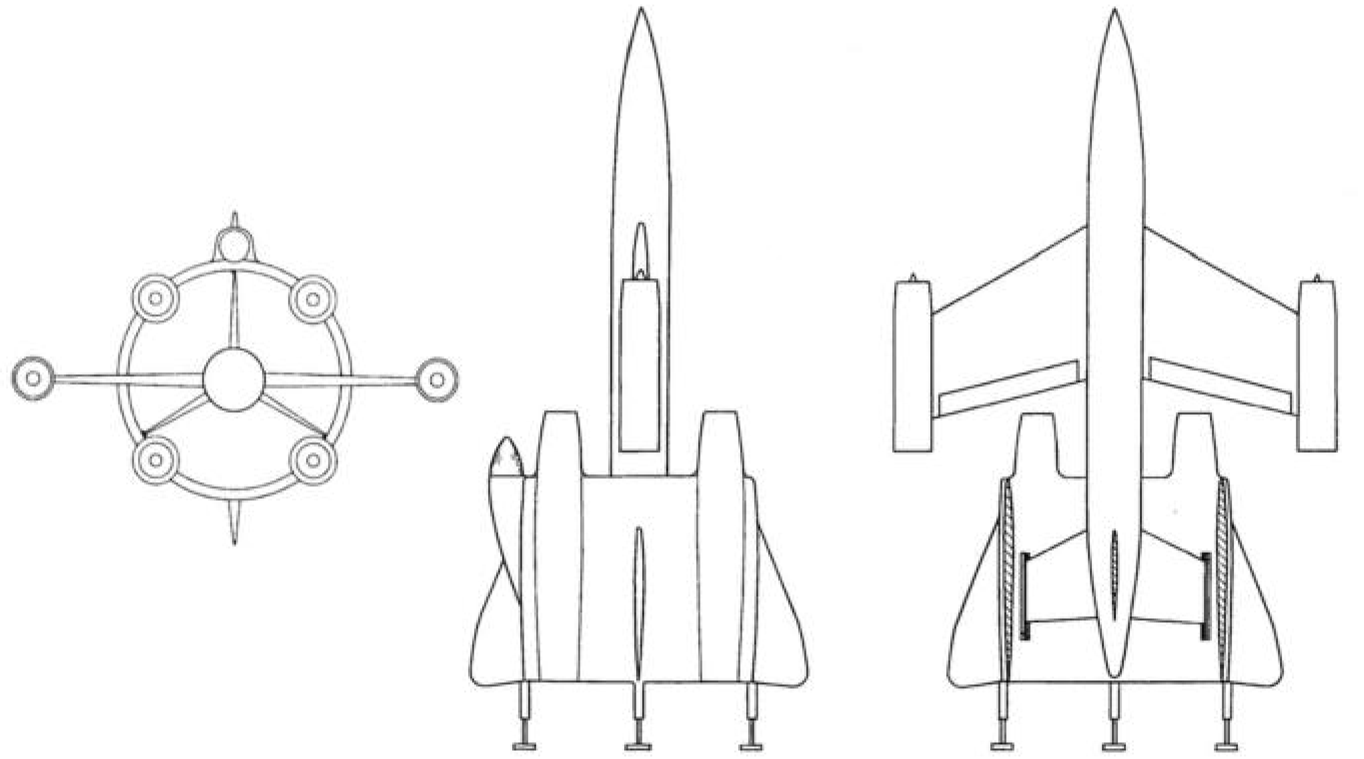
SNECMA then studied the possibility of building a supersonic VTOL fighter with delta wings called the AP519. Power was to be provided by two licence-built Pratt & Whitney JTF turbojets and the aircraft would have been supported by a complicated articulated undercarriage, allowing take-offs and landing from either an upright or horizontal position. A somewhat similar design was undertaken in West Germany by Focke-Wulf as the Fw 860. Models of the AP519 were wind tunnel tested but L'Armée de l'Air (The French Air Force) had selected the conventional Dassault Mirage 111V and this proved to be the last VTOL fighter project that SNECMA undertook.

Other SNECMA/BTZ studies that exploited the annular wing included several missiles, ranging from small battlefield anti-tank weapons to larger surface-to-air designs. Undoubtedly, the most unusual development of this concept was the proposal to build a small spacecraft launcher. It would have comprised a very large first stage annular wing booster powered by four powerful gas turbines with a ramjet capability. This part of the vehicle would have been fully recoverable. The concept was produced by Gerhard Eggers and Eric Haberkorn, who initially produced ideas for a manned and unmanned carrier aircraft capable of lifting smaller test vehicles to very high altitudes. Placing small satellites in Low Earth Orbit (LEO) was probably feasible, although the designers may have had a small manned vehicle in mind because this design was referred to in some SNECMA documentation as the Coléoptère spaceplane. However, it would have been difficult to convince anyone that this was a realistic alternative to an expendable liquid-fuel booster

In 1964 an American consultant engineer called James Reichert filed a Patent for a re-usable Ring Wing launch vehicle, which had similar aims to the SNECMA concept. Reichert had been Doak Aircraft's chief aerodynamicist, working on a number of VTOL projects, and was regarded as a leading

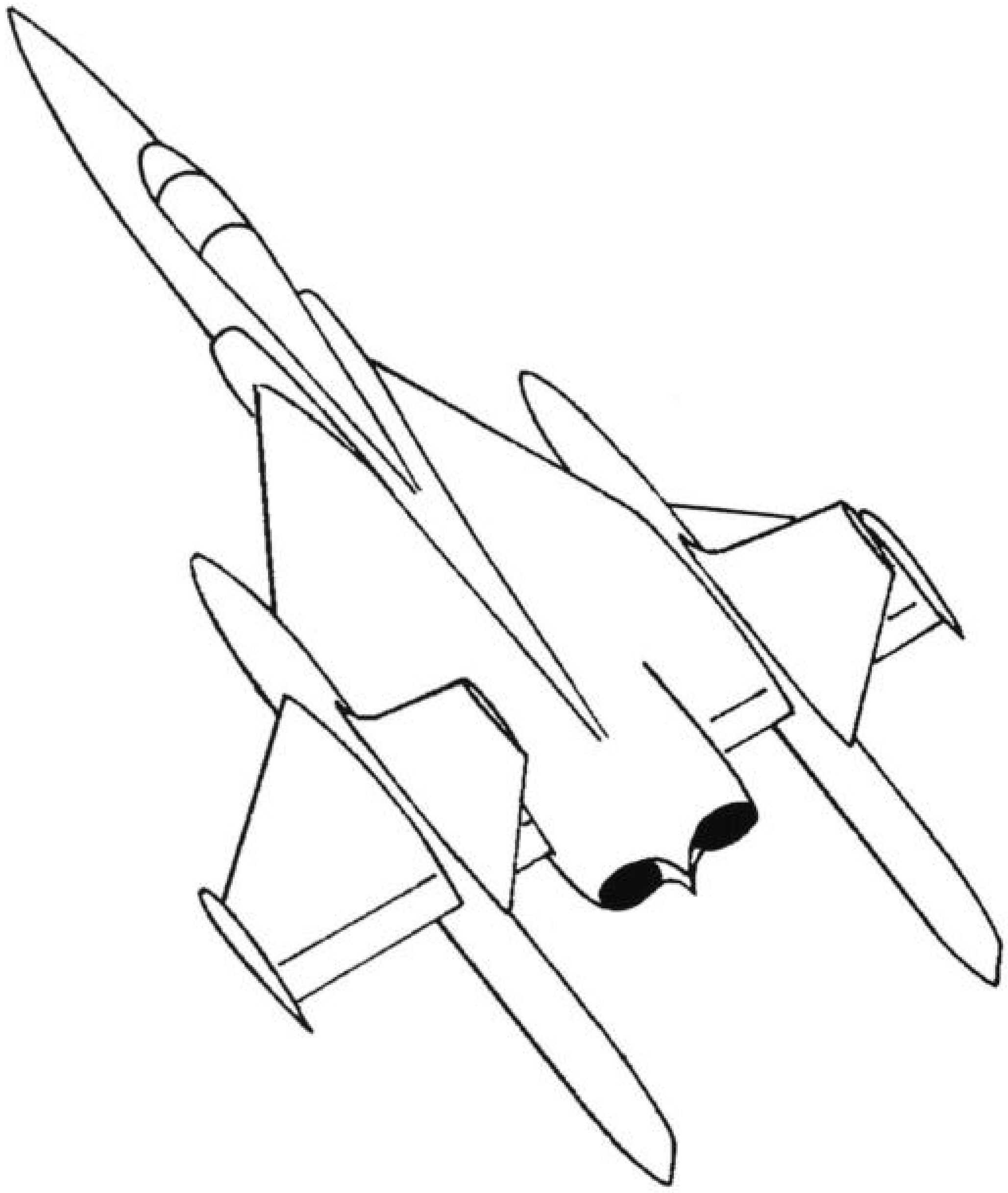


Left: **SNECMA AP.507 Mach 3 weaponised successor to C.450.** Bill Rose

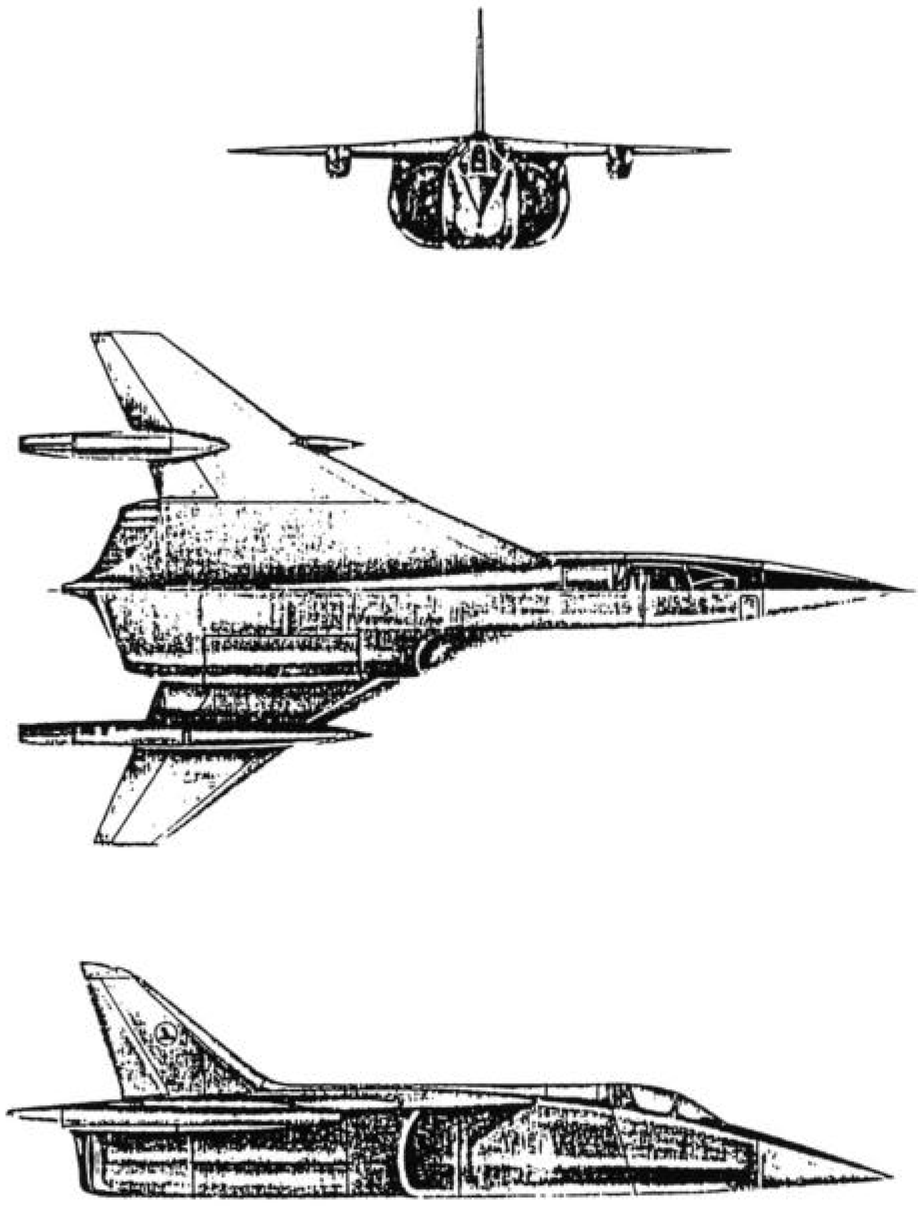


Lower left: **SNECMA/BTZ concept for a high-performance manned or unmanned VTOL carrier aircraft using an annular wing with multiple engines and addition wingtip propulsion. Designed by Gerhard Eggers and Eric Haberkorn as a means of carrying secondary vehicles to very high altitudes.** SNECMA

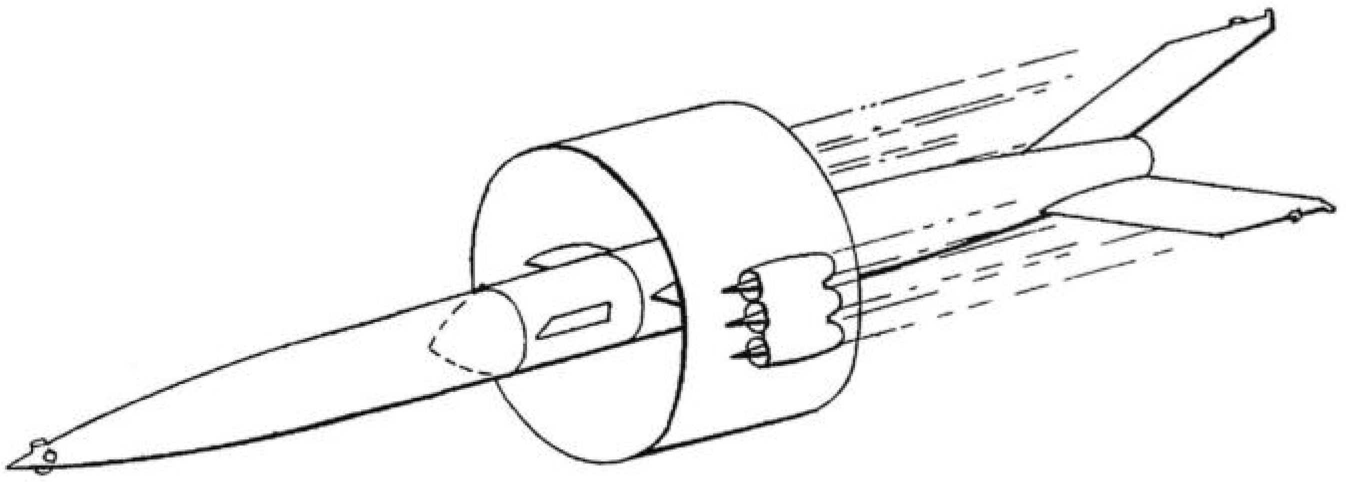
authority on ducted fan design. He would eventually join Lockheed's Skunk Works, taking responsibility for development of the radar absorption materials used on the F-117A. In his 1964 patent Reichert envisaged a manned rocket-shaped vehicle with three tail fins spaced at 120°. A rotating ducted fan annular wing was located at the centre of the vehicle, which was capable of propelling the craft to Mach 3. The forward section of the design was a detachable upper stage that would carry a modest payload into orbit. Needless to say there were no takers for Reichert's design.



Bottom left: **SNECMA AP.519 Final non-annular wing VTOL fighter concept.** Bill Rose, based on a SNECMA drawing



Bottom right: **The Focke-Wulf FW 860 VTOL interceptor proposal, developed alongside the SNECMA AP.519 as an alternative to the annular wing concepts.** via Bill Rose



Reichard annular wing space launch vehicle. US Patent Office

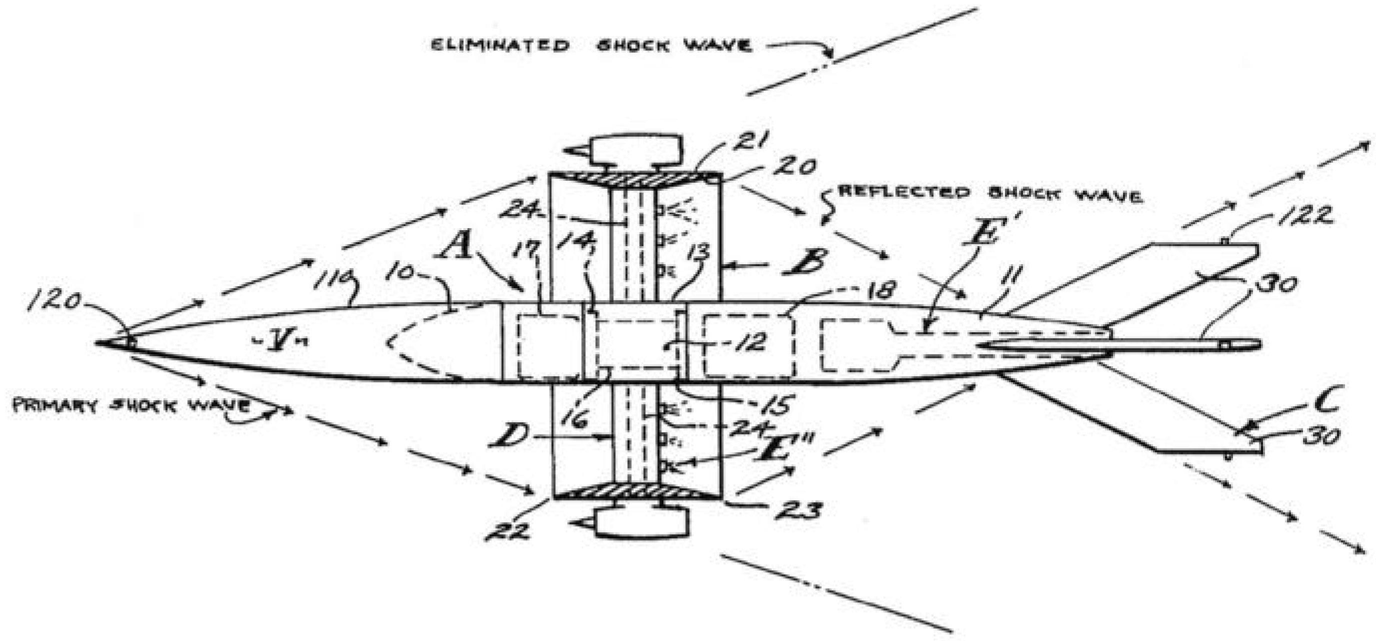


Diagram of shockwave patterns produced by James Reichard's annular wing space launch vehicle. US Patent Office

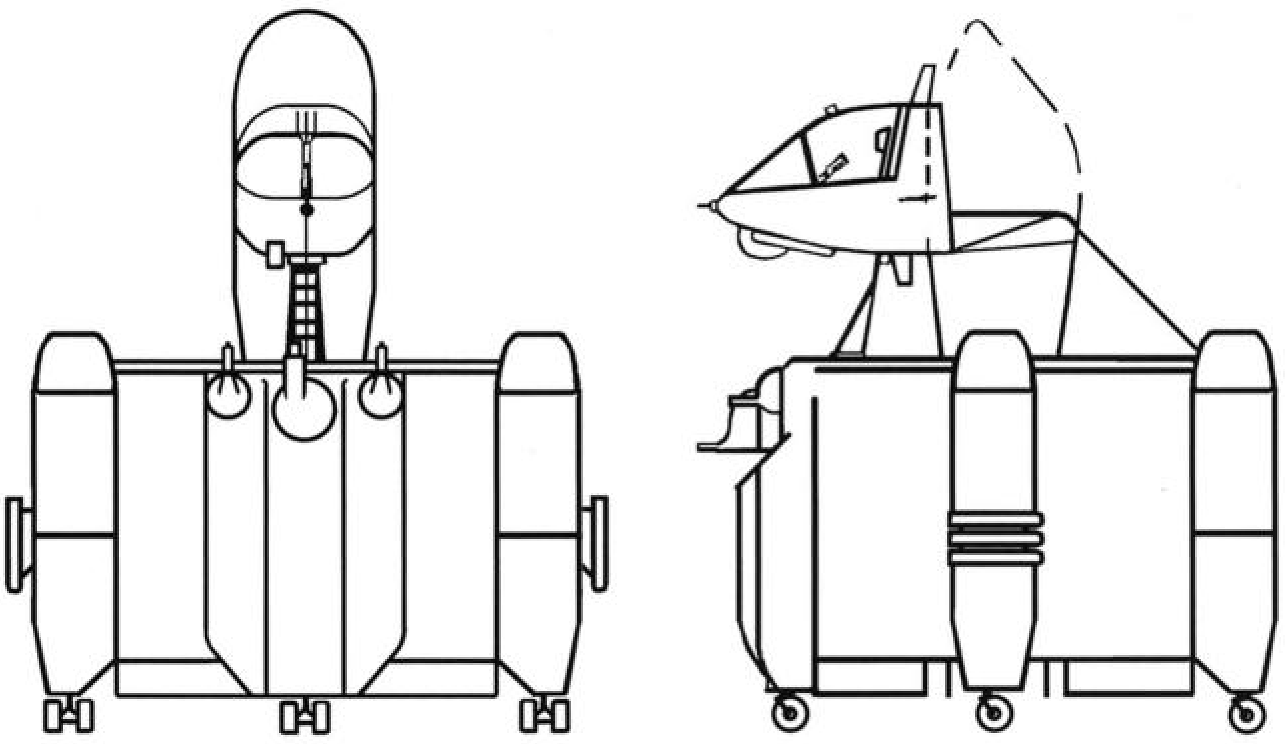
The destruction of the C.450 effectively finished the French programme and, although the Germans briefly revived some of Lippisch's annular wing proposals a few years later, these clever designs went no further in Europe. Zborowski continued to undertake consultancy work for German companies such as BMW and he died on 16th November 1969 at Brunoy, France.

Convair Model 49

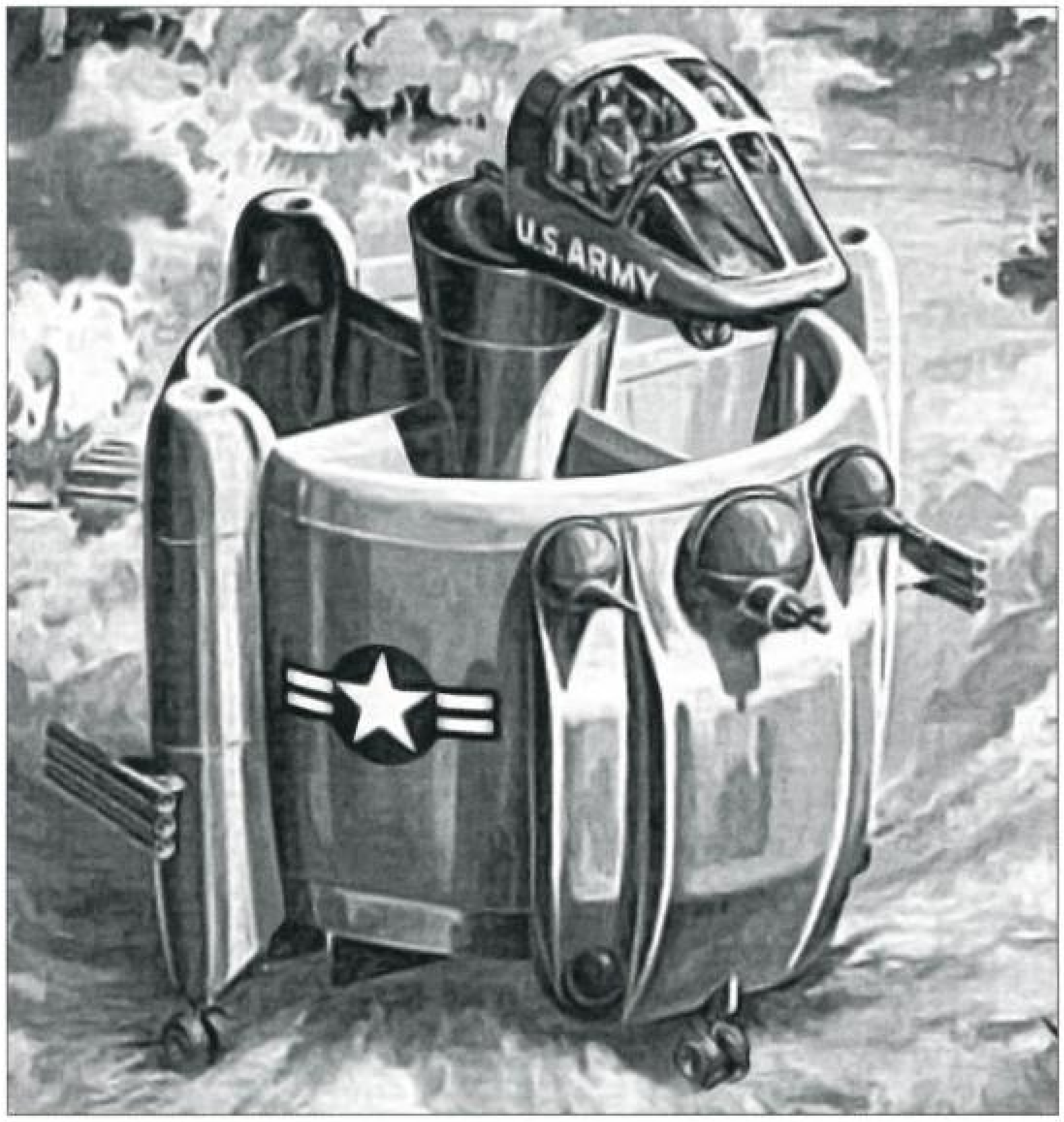
Starting in 1960 the US Army began to consider a new Close Air Support (CAS) aircraft because it was eager to break their dependence on the USAF who mainly used the Republic F-105 Thunderchief strike fighter in this role. Although the F-105D was considered to be a very capable delivery system by the USAF, the army felt that it was too fast in the close support role and they wanted a new heavily armoured VTOL aircraft with flexible performance and substantial firepower. This gave birth to a series of specifications for a new CAS design known as the Advanced Aerial Fire Support System (AAFSS), which were issued to a number of major defence contractors.

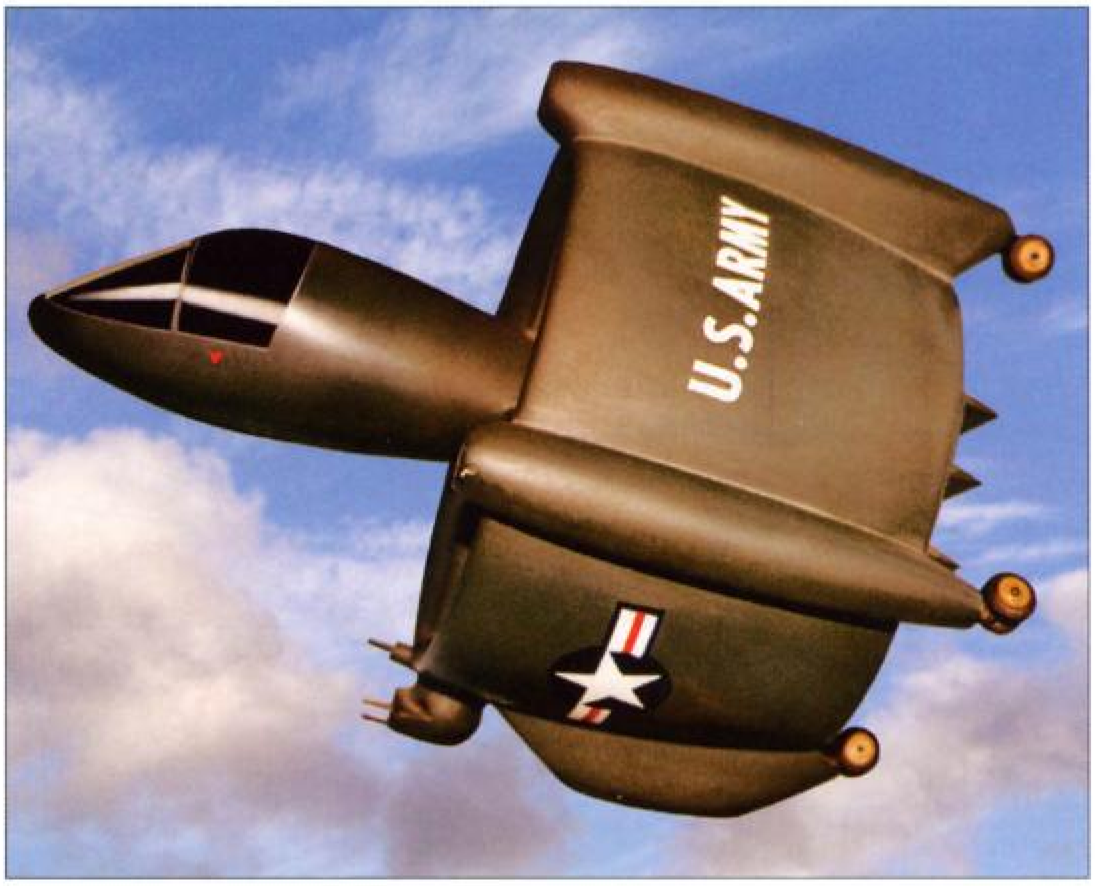
Convair at San Diego in California responded with an unusual proposal, which bore something of a resemblance to the SNECMA C.450 Coléoptère and some earlier BTZ designs. Known as the Model 49, this two-man annular or ring wing ducted-fan design seemed to fill the gap between a helicopter and fixed-wing aircraft, while also taking on some aspects of an armoured ground vehicle. The only obvious disadvantage was a tilting cockpit that made the Model 49 a very complex piece of engineering. The aircraft had an approximate overall length of 30ft (9.14m), reducing to 26ft 7in (8.1m) when the cockpit was fully tilted, and the wing diameter was 22ft 9in (6.93m). The suggested empty weight was 14,000 lb (6,350kg) rising to 21,000 lb (9,526kg) fully loaded, and the payload weight was estimated at 1,500 lb (680kg) to 5,000 lb (2,268kg).

Two co-axially mounted contra-rotating three-bladed rotors with variable pitch were located within the wing to propel the Model 49. Driving the rotors through clutches and gear reduction would be three turboshaft engines located in wing nacelles, which were capable of producing at least 3,000hp (2,237kW). First choice was the Lycoming LTC4B-11, with Pratt & Whitney's JFTD12, the General Electric T64 or Allison's T56 considered to be suitable alternative engines. The duct would enhance the level of thrust from the relatively small rotors and, although there was no cyclic pitch control, the aircraft was expected to handle like a helicopter but with better reliability. Pitch and yaw vanes were located inside the annular wing.



This drawing of the Convair Model 49 annular-winged VTOL combat vehicle shows the cockpit lowered in the right-hand illustration. Bill Rose





Left: **Convair Model 49 annular-winged VTOL combat vehicle. This illustration shows the vehicle in operational conditions with the cockpit lowered.** US Army

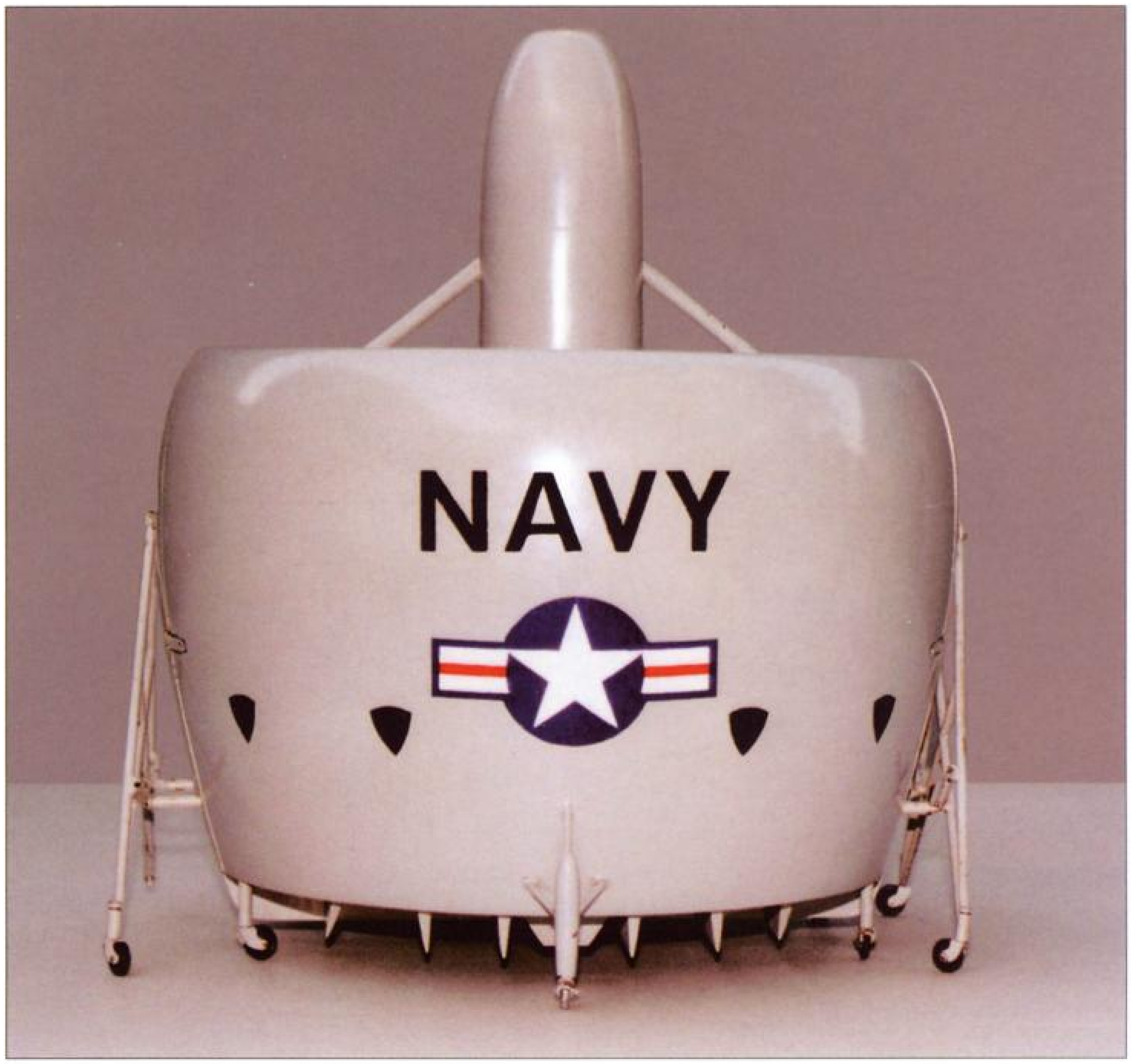
Above: **Convair Model 49 annular-winged VTOL combat vehicle, designed for the Advanced Aerial Fire Support System (AAFSS) Competition.** Allyson Vought / Bill Rose

During the early 1950s Convair had built an experimental VTOL fighter for the US Navy which was called the XFY-1 Pogo and it was hoped to draw on some of the expertise gained during this project to develop reliable control systems for the Model 49. A striking feature of the Model 49's design was the folding two-man capsule cockpit, which would be horizontal with the ground while the aircraft was in an upright position and move through 90° to retain this position for level flight. The aircraft would be heavily armoured with steel plating to protect the crew and its key systems against projectiles up to 12.7mm in calibre. However, this shielding would not have provided any protection against inexpensive shoulder-launched rockets fitted with high explosive anti-tank (HEAT) warheads, or other anti-armour weapons.

The proposed armament for this aircraft was considerable and would comprise two remotely controlled side turrets fitted with XM-134 7.62mm machine guns fed with 12,000 rounds of ammunition, or XM-75 40mm grenade launchers with 500 rounds. A third central turret contained an XM-140 30mm cannon with 1,000 rounds or a launcher for 500 WASP rockets. These weapons could be operated and fired from all positions including in the hover and in level flight. In addition four hardpoints were provided on two of the engine nacelles. These were suitable for 1,200-gallon (5,456-litre) fuel tanks, BGM-71 TOW missiles, Shillelagh missiles or a M40AC1C 106mm recoilless rifle with eighteen rounds. Performance estimates for the Model 49 suggest a maximum speed of 400mph (643km/h), a ceiling of 27,000ft (8,230m), an unrefuelled range of 450 miles (724km) and an endurance of about two hours and fifteen minutes.

The initial study progressed to the construction of a small proof-of-concept demonstrator, which flew in 1962 and was apparently incredibly noisy. The unconventional Model 49 finally lost out to the advanced, complex and very expensive Lockheed AH-56A Cheyenne attack helicopter, which in turn lead to the all-weather McDonnell Douglas AH-64 Apache.

Lockheed AH-56 attack helicopter chosen as winner of the Advanced Aerial Fire Support System (AAFSS) competition in preference to the Convair Model 49. A small number of the aircraft were built and tested, but they were complex and expensive, so never entered production. However, the AAFSS eventually lead to development of the Apache helicopter. US Army



Small UAV concept developed by Convair from the Model 49 Project. In this photograph, the control vanes are clearly visible below the rotors. John Aldaz

Convair LALO/PEEK

Convair used the Model 49 design to produce studies for two smaller UAVs, intended for battlefield surveillance and naval ASW operations. The Convair LALO (Low Altitude Observation System) was devised for the US Army Electronics Command and the study was completed in 1965. LALO would have carried a compact TV camera, which would primarily be used for target designation. LALO's dimensions were; length 8ft 2½in (2.53m), diameter 5ft 9in (1.75m) and it contained 4ft 6in (1.37m) rotors. The empty weight of this vehicle was 263 lb (119kg) and it carried a 75 lb (34.0kg) payload and 50 lb (22.6kg) of fuel. The vehicle would have been powered by a McCulloch two-stroke, six-cylinder reciprocating engine that produced 158hp (117kW). LALO was expected to have a maximum speed of 138mph (222km/h), a ceiling of 10,000ft (3,048m), a maximum range of 25 miles (40km) and an endurance of one hour. The UAV could be handled by two men and transported by a suitable Army ground vehicle.

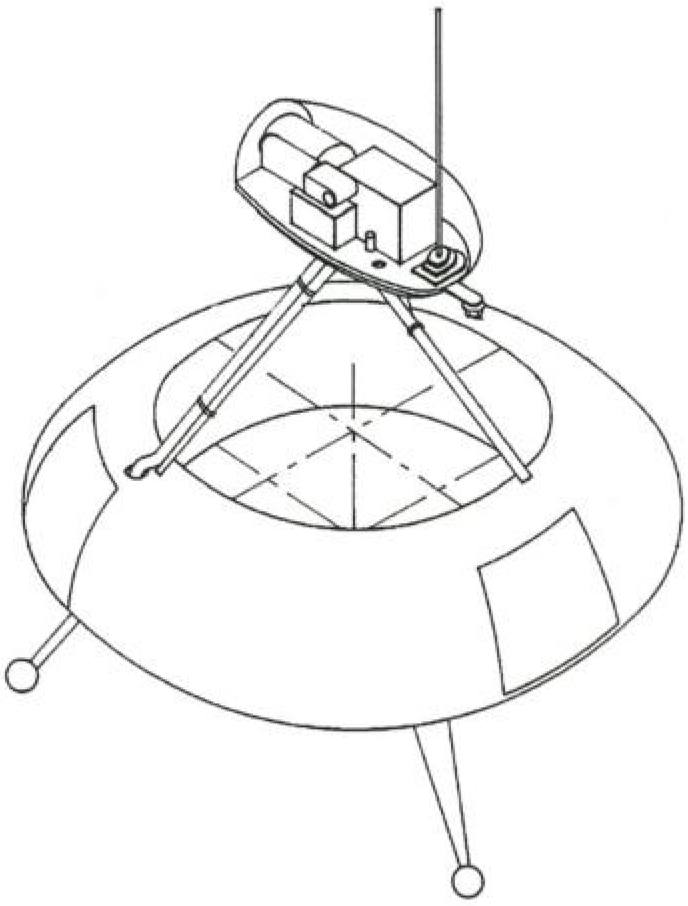
A derivative of LALO was the Convair PEEK (Periodically Elevated Electronic Kibitzer) that was intended to take a brief look at possible targets and then duck out of sight. A slightly larger version was studied for shipboard use in an anti-submarine warfare role. It may have been armed with a torpedo, but little is known about this particular concept and none of these UAV studies progressed to prototyping.

Sikorsky Cypher

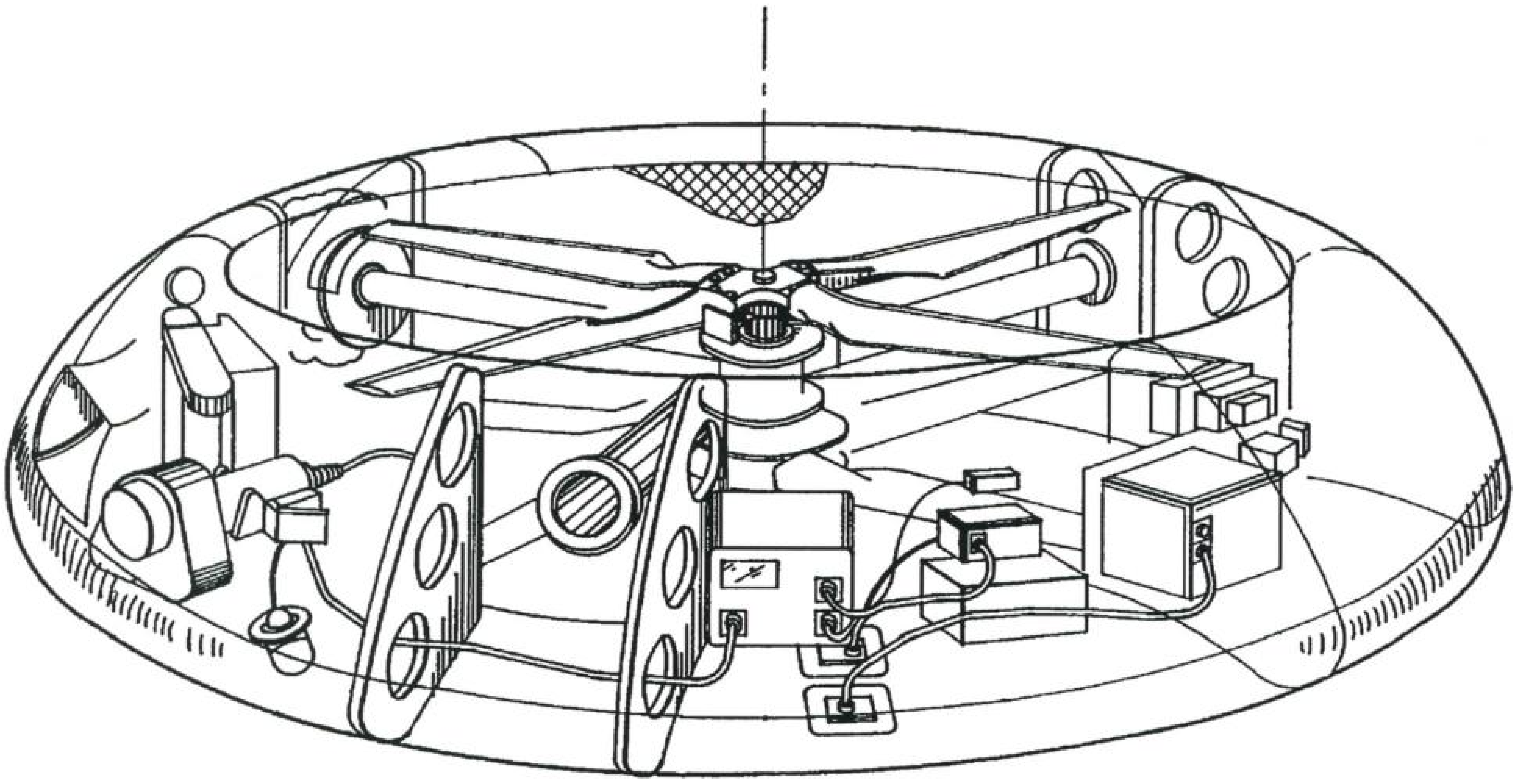
In 1987 the Sikorsky Aircraft Corp (who are a division of United Technologies Corp) started the development of an UAV that was initially known as 'The Flying Doughnut'. The chief designer behind this project was James P Cycon, who was assisted by Ken Rosen and Andrew Whyte. Their brief was to build a small and easily transportable drone, primarily for military use, which would have a full VTOL performance together with adequate endurance. Using a toroidal flying saucer shape, this small aircraft was powered by centrally ducted four-bladed coaxial rotors that were based on a Sikorsky design dating back to the early 1970s. A key requirement of this UAV was the enclosure of the rotors to make the machine safer to handle and easier to fly thorough constricted areas, such as gaps between trees or buildings. The vehicle's housing also reduced noise while the rigid (as opposed to articulated) counter-rotating rotors avoided torque problems; in addition collective and cyclic pitch provided control for lift-off, hover and level flight.

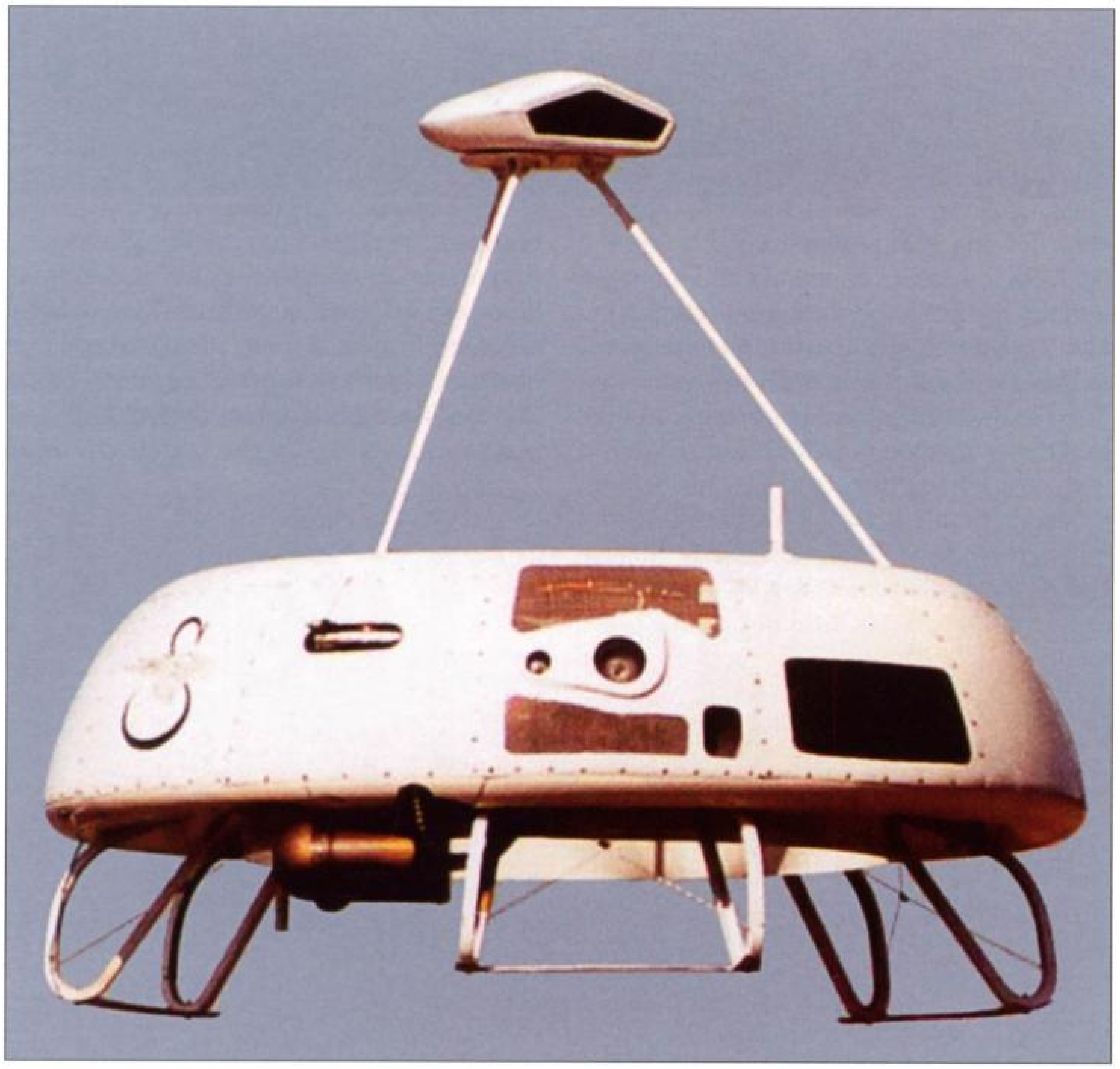
A scale-sized proof-of-concept model called the Cypher was built and tested in mid-1988. It had a diameter of 5ft 9in (1.75m), a height of 1ft 9½in (0.55m) and a weight of 44 lb (19.6kg). The propulsion system was driven by a small 3.8hp (2.8kW) four-stroke engine, although this level of power proved totally inadequate for the trials. However, enough data was gathered to determine the viability of the concept and a decision was taken to build a full-sized Cypher vehicle with a more suitable engine.

The second Cypher prototype was 6ft 2½in (1.89m) in diameter, had a weight of 242 lb (110kg) and was powered by a compact 53hp (39.5kW) Wankel rotary engine. Testing began in 1993. The shroud was manufactured from composites and Cypher could carry equipment payloads of 40 lb (18.1kg) that could be tailored to specific missions. With foldable landing legs the aim was to make the UAV easy to handle by a small support team and readily transportable. Cypher used a fly-by-wire system, integrated avionics and a supposedly unjammable data link, plus an onboard computer capable of varying degrees of autonomous behaviour such as auto take-off, auto landing, hover hold and auto return home. Cypher could navigate precisely in any chosen area by means of the onboard Global Positioning System (GPS).



Drawing showing early layout proposal for Sikorsky Cypher UAV. Sikorsky Aircraft Company





Schematic showing early internal layout for the Sikorsky Cypher I. Sikorsky Aircraft Company

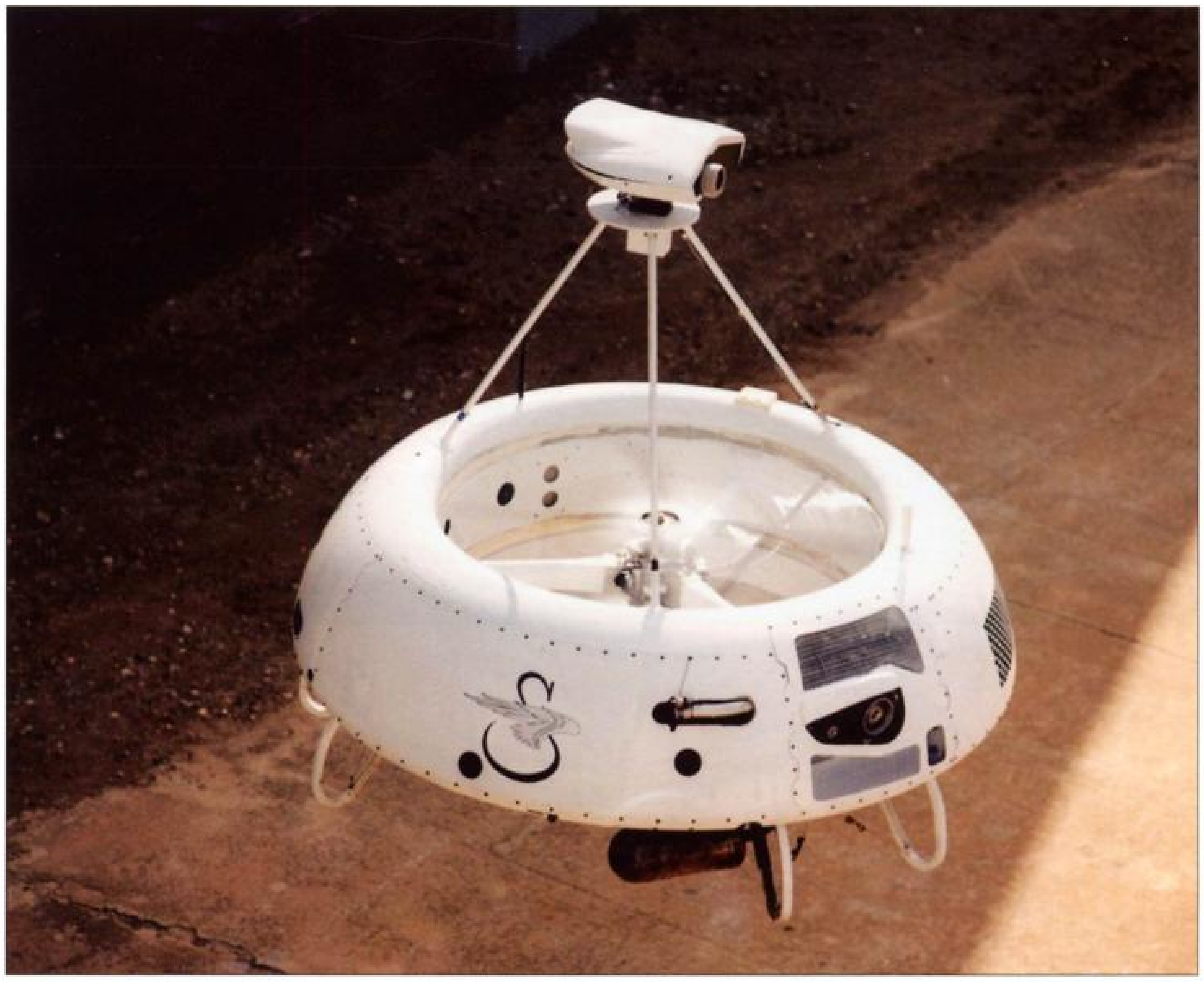
A test flight in 1997 of the unmanned Sikorsky Cypher I vehicle by the US Army. US Army

However, this machine with its payload was primarily designed to be controlled by a single operator, monitoring the flight from no more than a laptop computer running Windows software with a connection to the UAV via a digital telemetry link. Cypher's shape helped to reduce the vehicle's radar signature and it had a maximum speed of 81mph (130km/h), a ceiling of 8,000ft (2,438m), a three-hour endurance in hover mode and an operational range of about 15 miles (24km).

A prolonged period of development followed the completion of the first prototype, and Cypher also participated in the US Army's Autonomous Scout Rotorcraft Test-bed (ASRT) demonstration programme. This led to the US Army's Force Protection Equipment Demonstration in Virginia during 1997. Cypher was used in many simulated roles and with various different payload packages designed for reconnaissance, surveillance, jamming, decoy, communications relay, fire control and re-supplying small payloads of critical equipment. Highly specialised sensors have also been tested to detect NBC threats and to remotely examine underground structures. A standard sensor package developed for this UAV comprises of a visible light video camera, an infra-red video camera and a laser rangefinder mounted on a pan-and-tilt head, supplemented with a separate acoustic pick-up. A 360° coverage is possible with + or -30° elevation or depression for video surveillance.

Sikorsky attempted to interest police forces and the media in this UAV, but it became clear that further work was required to iron out some of the bugs present in the design. There were two important issues to resolve

The Sikorsky Cypher I hovers a few feet above the ground during a test flight undertaken by the US Army. US Army

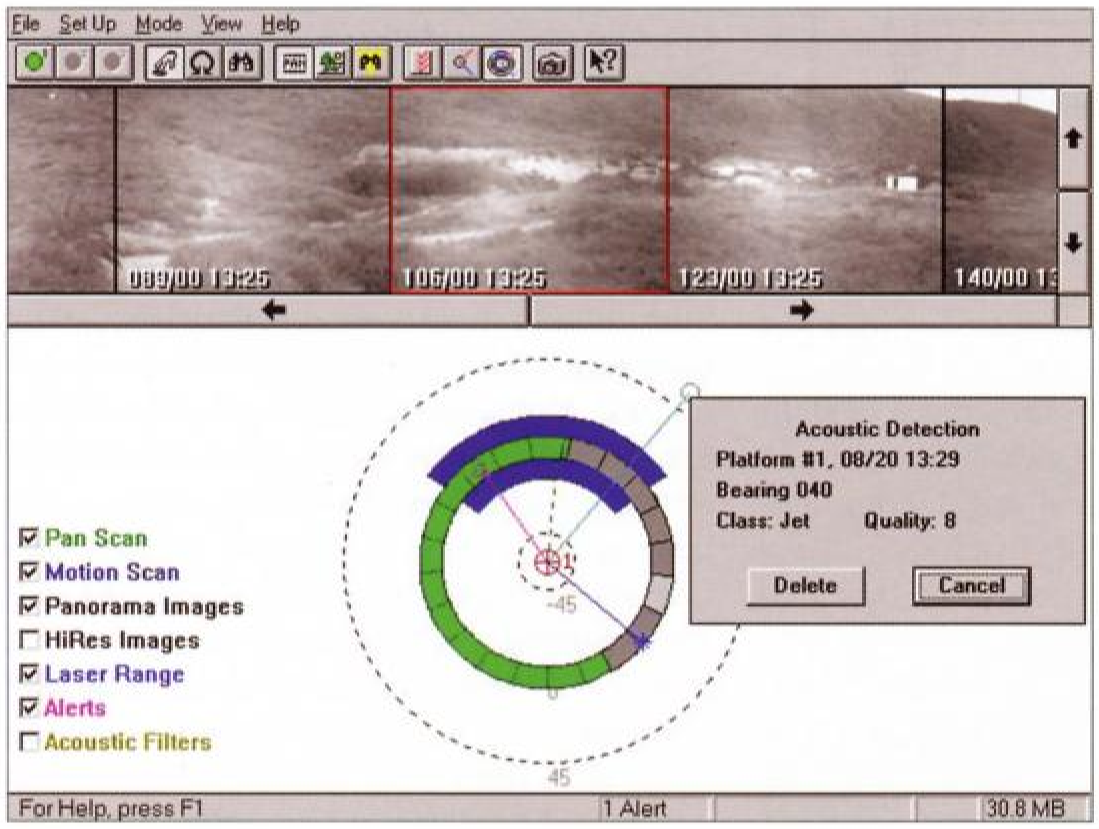


and the first was the UAV's relatively slow speed in forward flight due to the total reliance on rotor thrust for this function. There were also problems of occasional nose-up pitching which needed to be addressed. The solution to these difficulties seemed to be a separate rotor for level flight and alterations to the aerodynamics of the UAV's toroidal fuselage. Another method of counteracting the nose-up pitching moment in this design was by using short wings capable of generating additional lift.

By late 1998 James Cycon had come up with a host of improvements to the original design that would correct most of these problems, and in addition it was now possible to provide the UAV with a top speed of 144mph (232km/h), a range of 115 miles (185km) and the ability to loiter for two hours. The payload capability could be marginally increased to 45 lb (20.4kg) and the dimensions would be revised to a length of 6ft (1.83m) with a wingspan of 8ft 7in (2.62m); these measurements still allowed the entire system to be transported by one Humvee and its trailer. This revised design, which used an additional ducted pusher propeller and (optional) stubby wings, was named Cypher II. Two prototypes plus their ground stations were ordered for further testing by the US Marine Corps in September 1999, under a $5.46 million contract.

Cypher II was now re-named Dragon Warrior by the US Marine Corps Warfighting Laboratory (MCWL), who took out an option with Sikorsky for ten additional production UAVs. Assembly of these prototypes began at Stratford, Connecticut, with a small amount of work being completed at West Palm Beach, Florida. However, in 2002 the Defense Advanced Research Projects Agency (DARPA), who sponsored this project, decided to withdraw funding and Cypher was subsequently abandoned. Nevertheless, Sikorsky Aircraft is now teamed with Raytheon to develop a new all-weather remotely controlled vehicle for the US Marine's Unmanned Combat Armed Rotorcraft [UCAR] project.

Raytheon will use its experience gained during systems development for the Global Hawk and Predator to provide advanced multi-spectral sensors, weapons systems and improved command and control technology. This should lead to a low-observable vehicle capable of conducting offensive operations with a high degree of autonomy. The other defence contractors competing include Lockheed Martin, Bell Helicopter Textron, Boeing and Northrop Grumman. The final phase should be completed in 2009, with an operational system ready by 2012.



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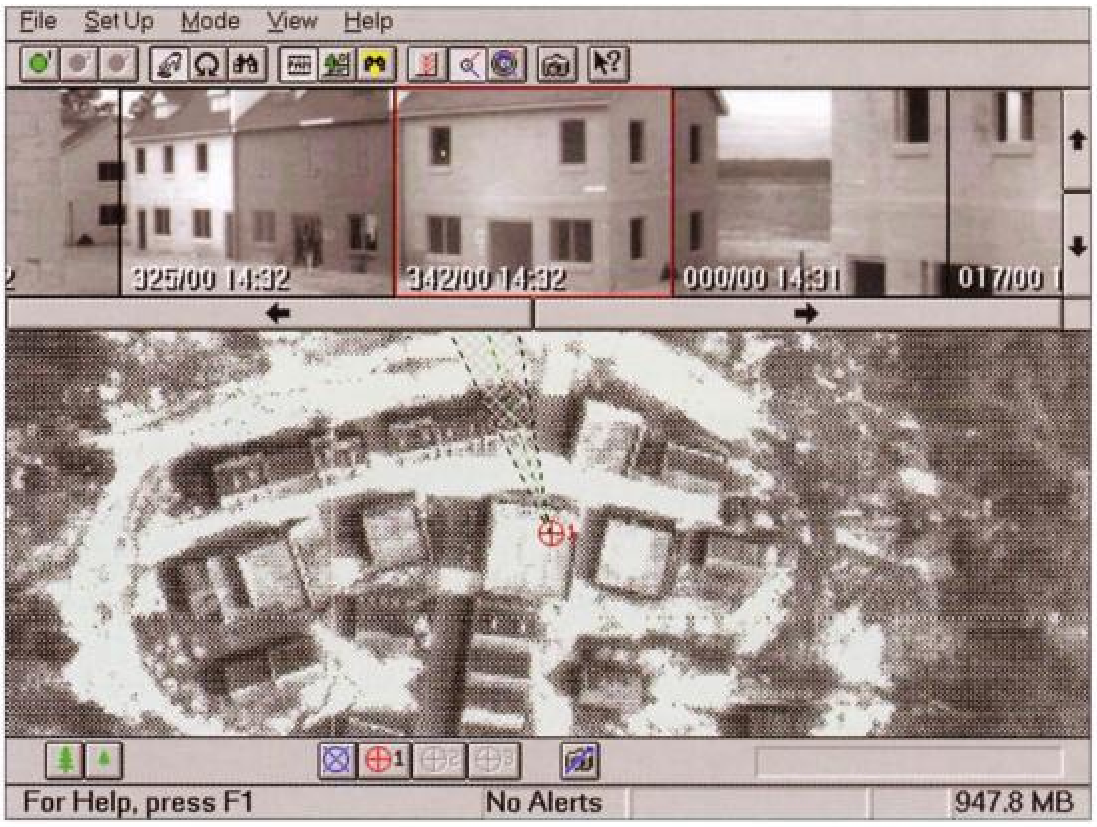
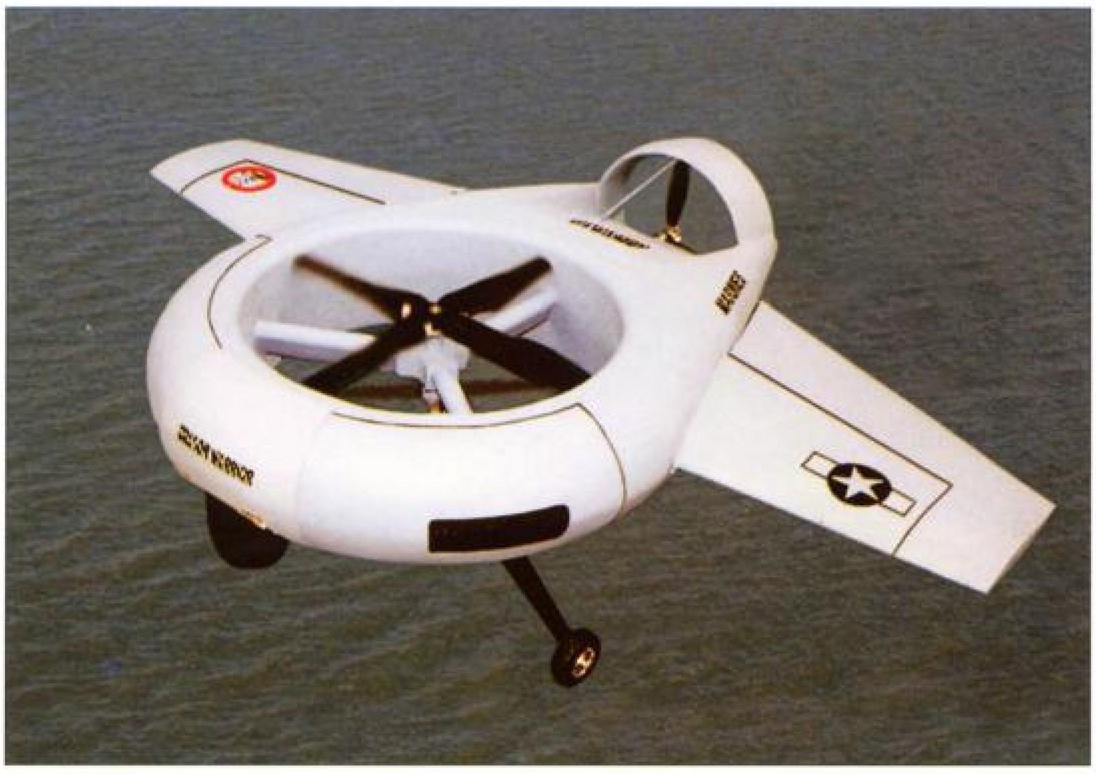
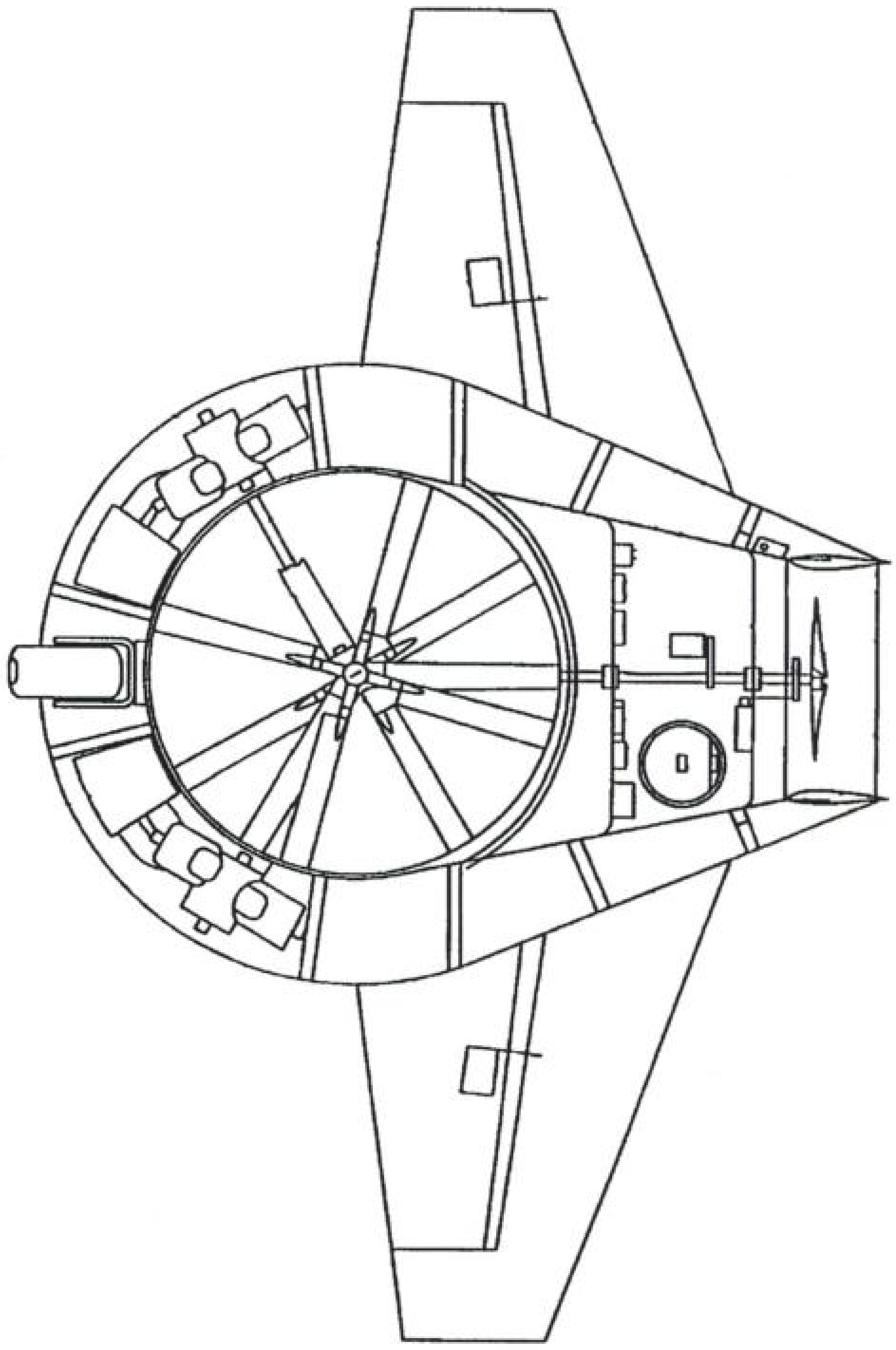
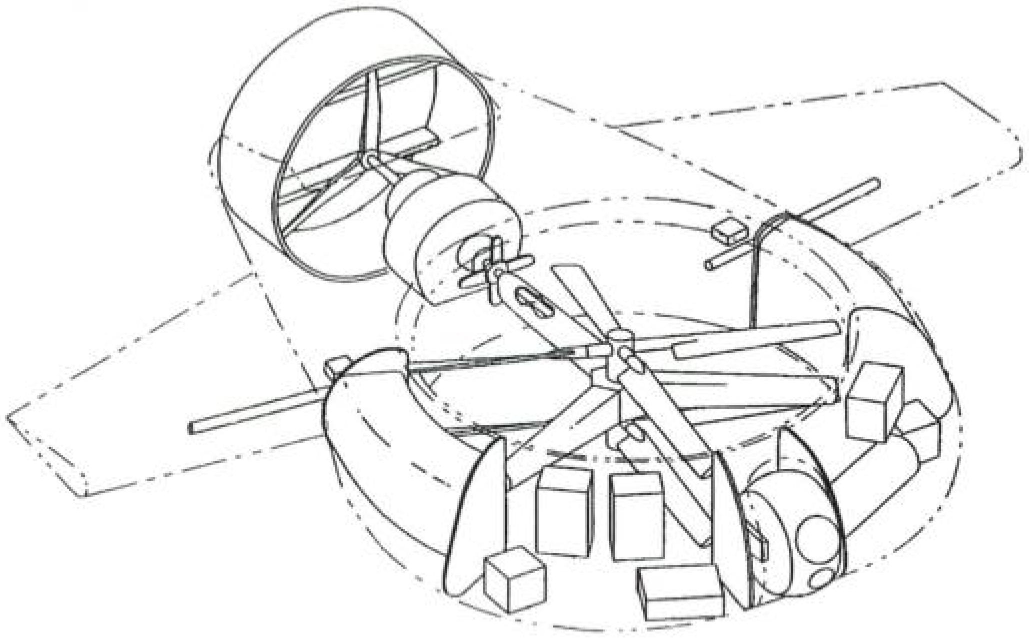
Software used to control Cypher I. This runs under a normal Windows operating system on a laptop computer. US Army

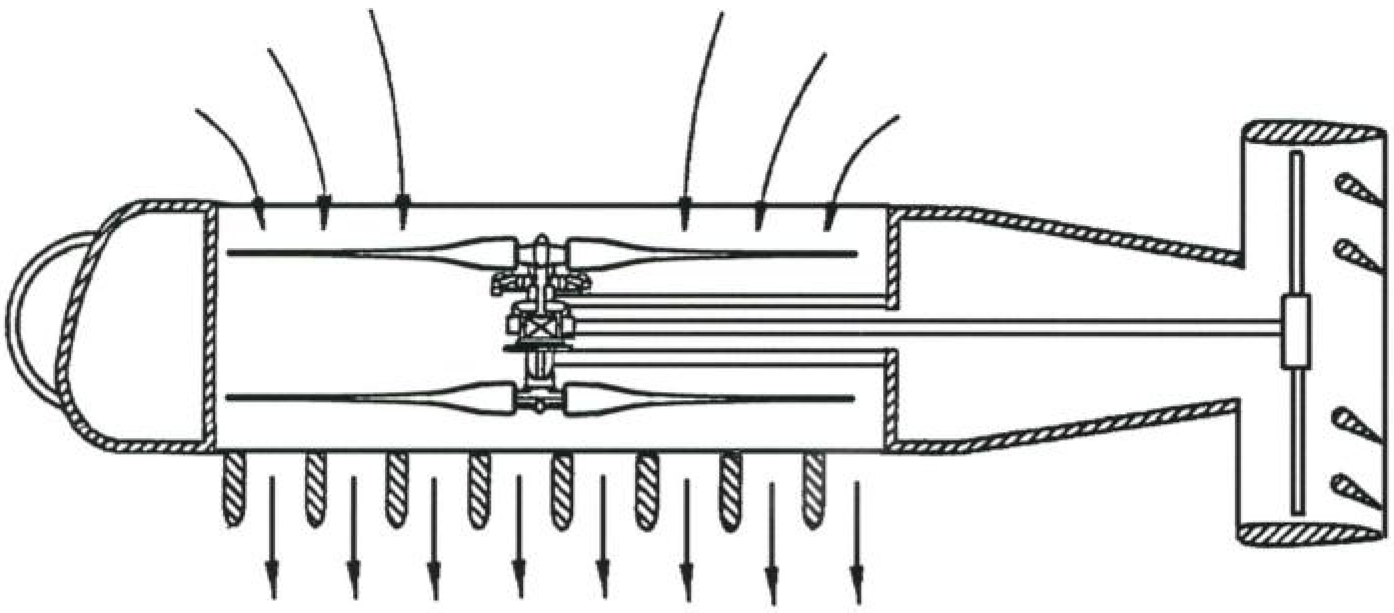


Images returned (top) from the sensor system fitted to the Sikorsky Cypher I UAV. US Army









Top left: **The more advanced twin propulsion winged Sikorsky Cypher II.** US DoD

Above left: **Key internal features of the winged Sikorsky Cypher II.** Sikorsky Aircraft Company

Above right: **Initial layout proposal for the Sikorsky Cypher II.** Sikorsky Aircraft Company

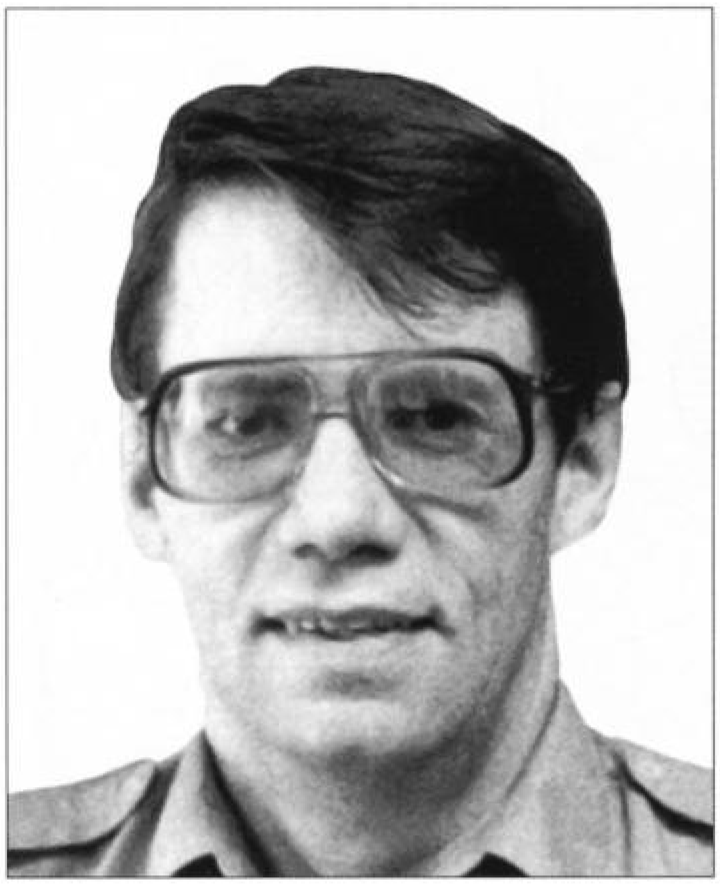
Left: **Cross-section of Sikorsky Cypher II showing features of the rotor propulsion system.** Sikorsky Aircraft Company

Moller

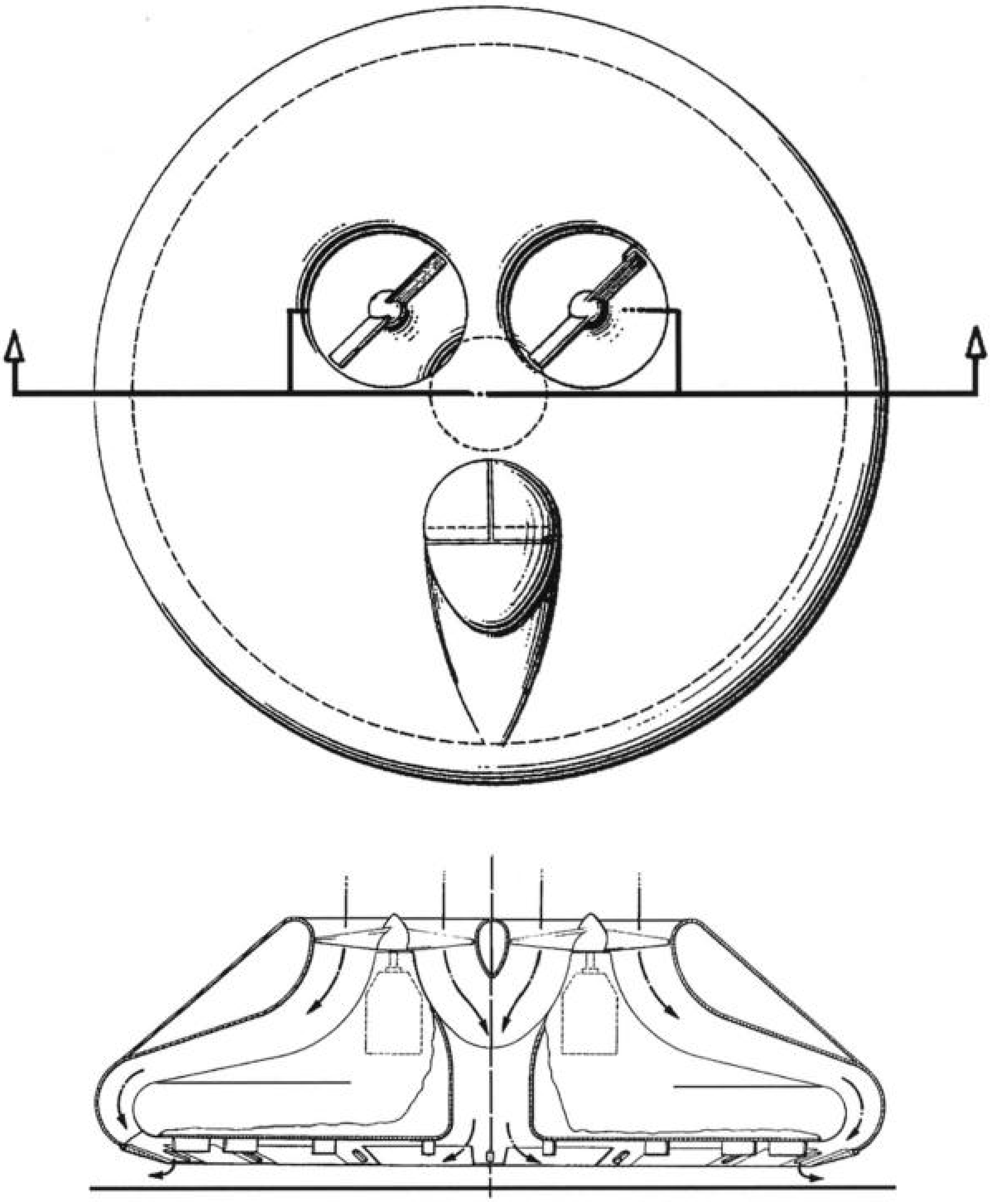
Canadian-born inventor Paul S Moller grew up with aspirations of building his own personal aircraft capable of VTOL. Having graduating from High School, Moller went on to undertake a three-year course on aircraft maintenance with Trade School and finally joined the Canadair Aircraft Company in Montreal as an engineer. He then met Professor Barry Newman from McGill University who invited him to join his undergraduate programme, where he eventually graduated with a Masters in Engineering and a PhD. In 1963 Dr Moller joined UC Davis in California as a professor of mechanical engineering and spent the next eleven years teaching.

A year after joining the college he began to transform his VTOL aircraft concepts into something more positive. First of all he set up a business called The Moller Aircraft Company and then began the construction, in his garage, of a compact prototype aircraft called the XM-2. XM-2 was a one-man 14ft (4.27m) diameter disc-shaped vehicle weighing 700 lb (317kg). It used a ducted fan system for propulsion, powered by two McCulloch engines, and there were opening flaps on the underside of the craft to provide directional control. Moller believed that failure of one engine in flight would not prove catastrophic and it would still be possible to make a safe landing.

In 1966 Moller filed a US Patent (3,410,507) for this design and the XM-2 flew for the first time that same year. Unfortunately, the machine never rose much higher than about 3ft (0.91m) from the ground and was reportedly rather unstable in operation. XM-2 was intended to be more than a ground effect vehicle, but lacked adequate engine power



Above: **Dr Paul Moller, who has been responsible for designing an intriguing series of ducted fan VTOL aircraft.** Moller International



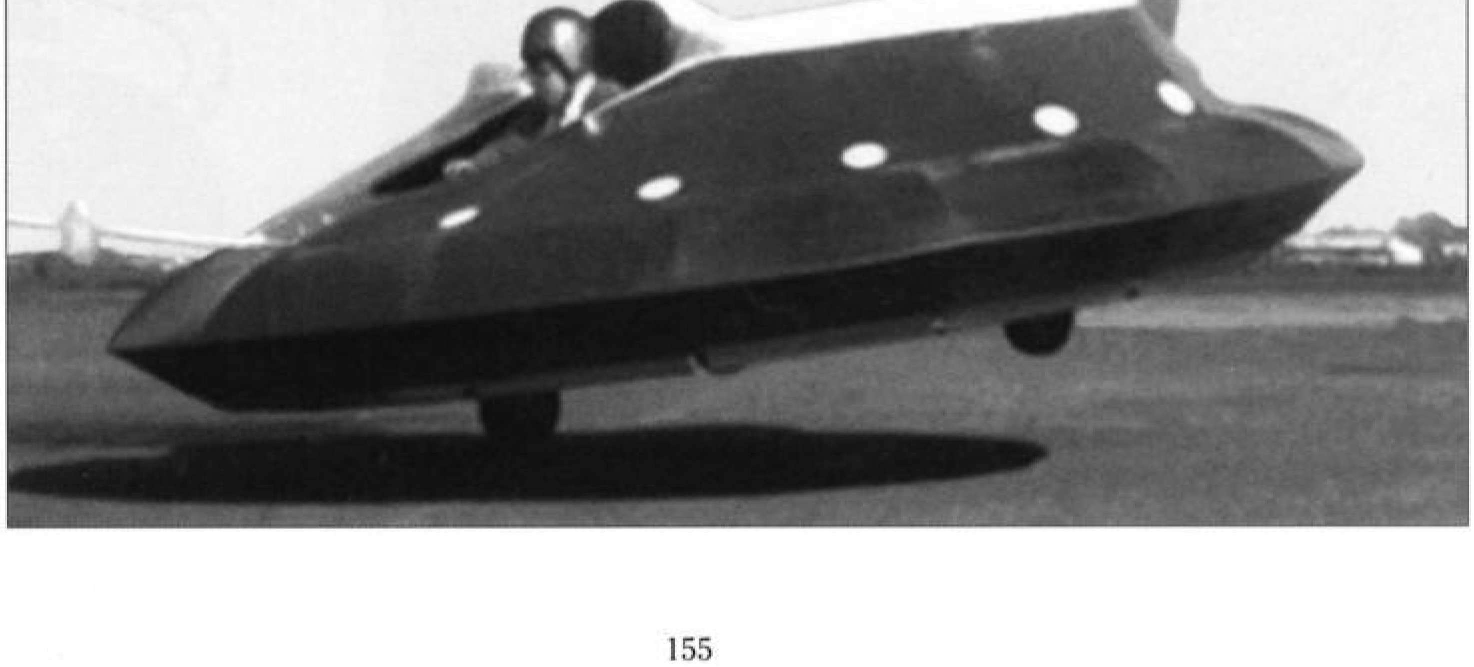
Right: **Initial proposals for the Moller XM-2.** Moller International

to fly like an aircraft. To improve matters the McCulloch engines were replace by Mercury outboard motors, but XM-2 was still grossly underpowered and it was decided to build a second prototype, called the XM-3. This was completed in 1968 and it used a single ring fan powered by eight small go-cart engines. When XM-3 flew it proved very stable and could undertake 360° turns without any difficulty, but it still lacked sufficient power to lift much higher than 10ft (3m) from the ground.

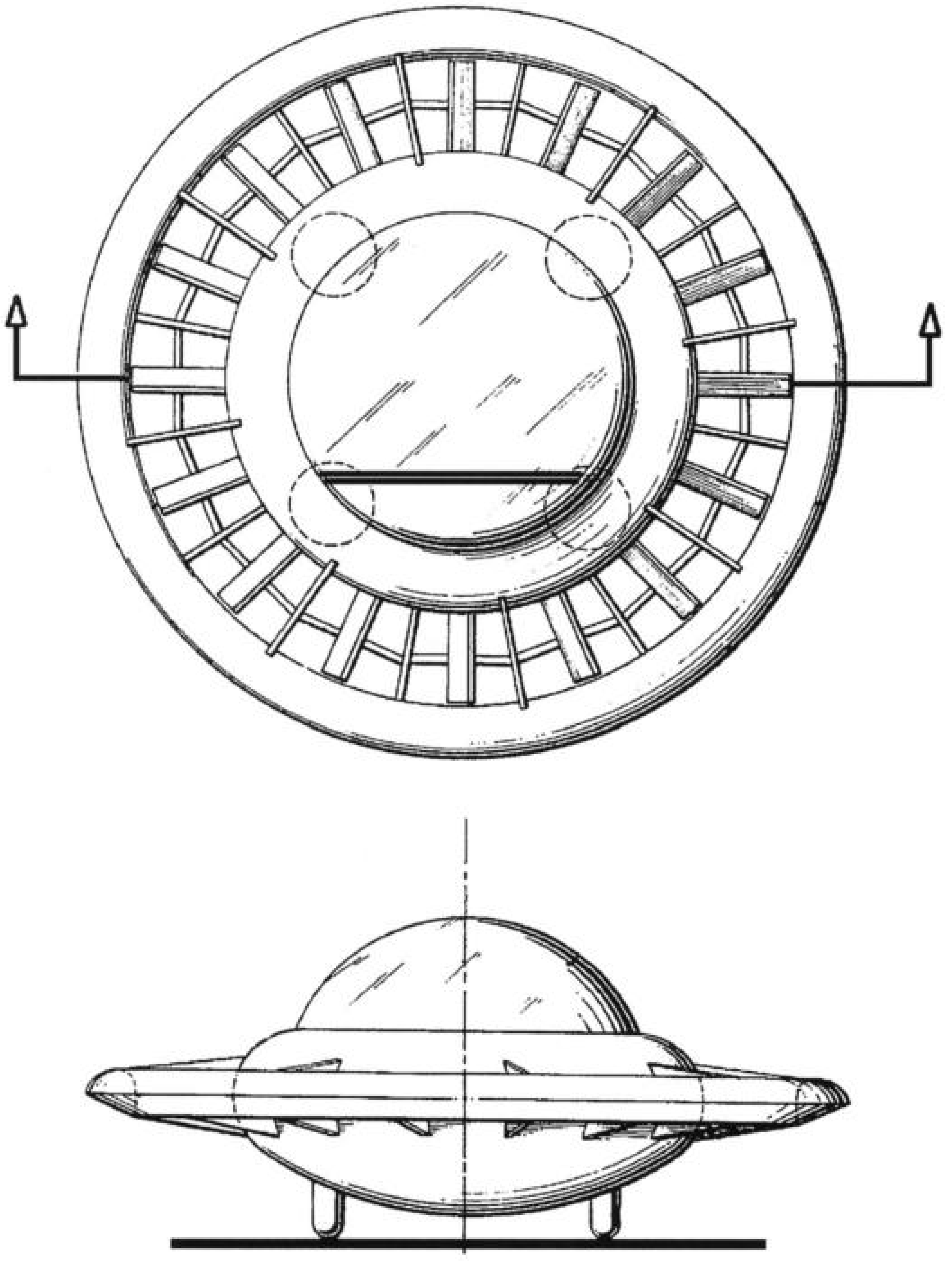
Moller followed this with a two-person, eight-engined prototype called the XM-4. Each ducted fan had the ability to tilt between 2° and 4° from its central axis to provide directional control. A US Patent for this design (3,614,030) was filed in 1969 and the goal for XM-4 was to lift a payload of 1,000 lb (454kg) and achieve a level speed of 300mph (483km/h) at a reasonable altitude. XM-4 was built at an industrial unit in Davis, California. It was completed in 1969, although a lengthy period followed when the project was on hold. The first hover trials using 300cc Wankel rotary engines took place in 1974, but the engines only produced enough power to lift the platform to an altitude of about 40ft (12.2m) and the original design goal remained a long way from realisation. Development of the XM-4 continued at a snail's pace for the next ten years until new more powerful Wankel rotary engines were fitted and the vehicle was renamed M200X.

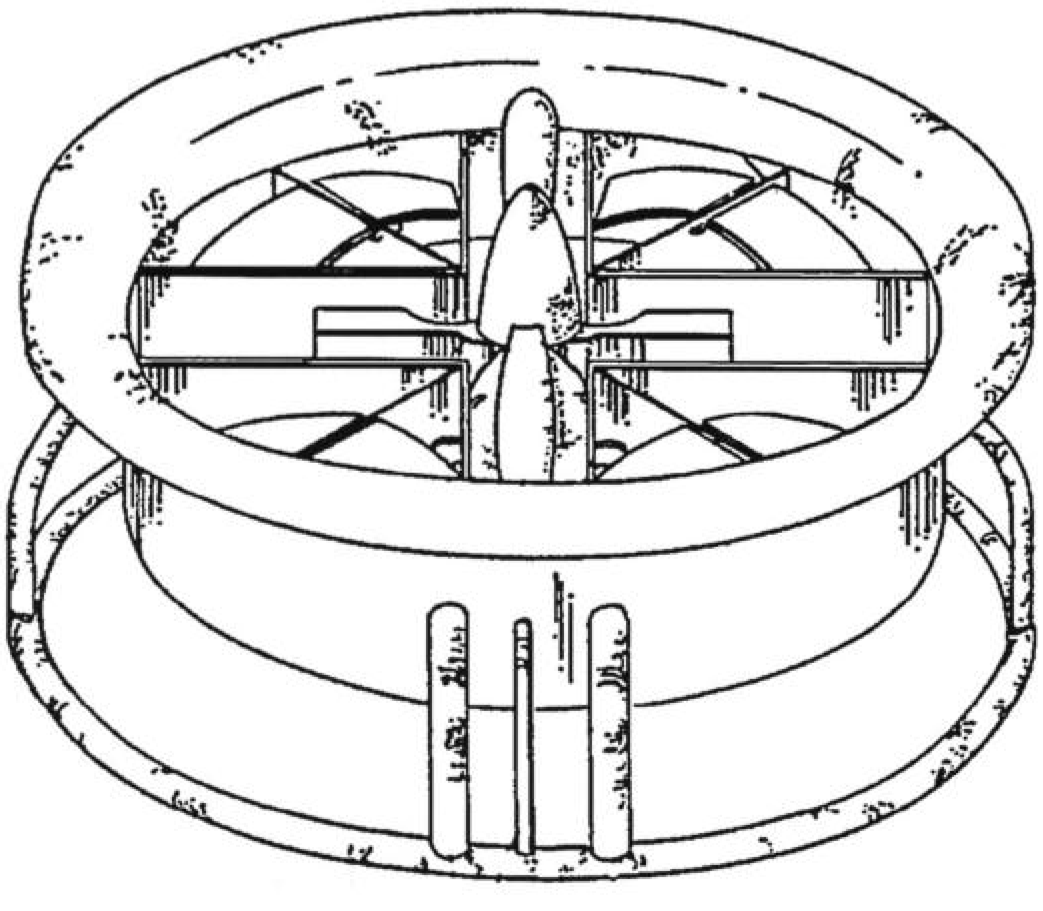
By 1990 the M200X had made over two hundred flights, often with Dr Moller at the controls, although the aim of achieving level flight at a significant altitude remained elusive. Moller's company was now involved in the development of small UAV aerial vehicles using ducted fan propulsion driven by a rotary engine. These compact aircraft, called Aerobots, are understood to have been built for US Navy and DARPA programmes but have yet to enter production.

Dr Moller has continued to pursue his dream of perfecting a simple inexpensive air transportation system and his current prototype is called the M400 Skycar. This widely publicised automobile-sized vehicle uses



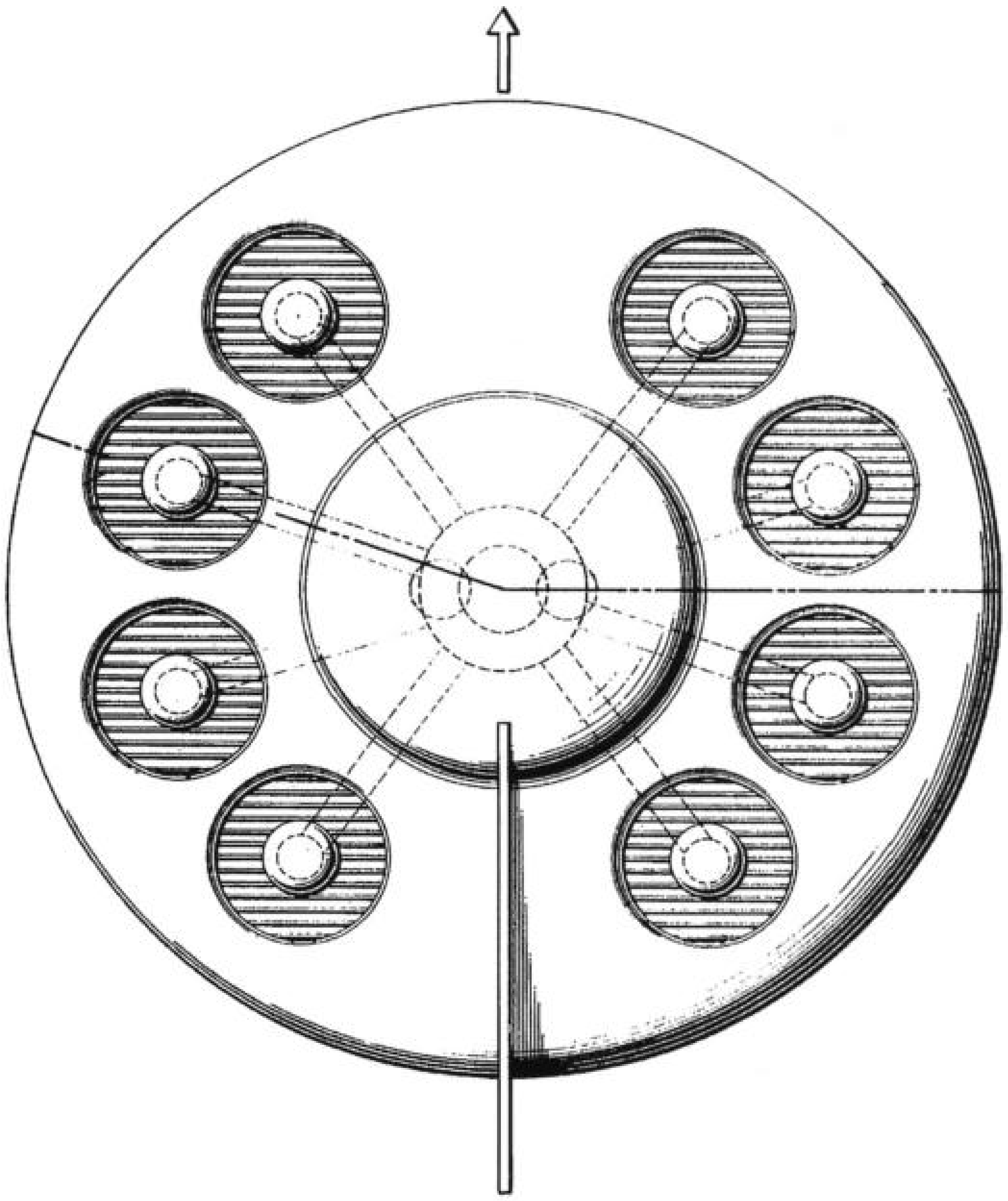
Early test flight of the experimental Moller XM-2 test vehicle. Moller International

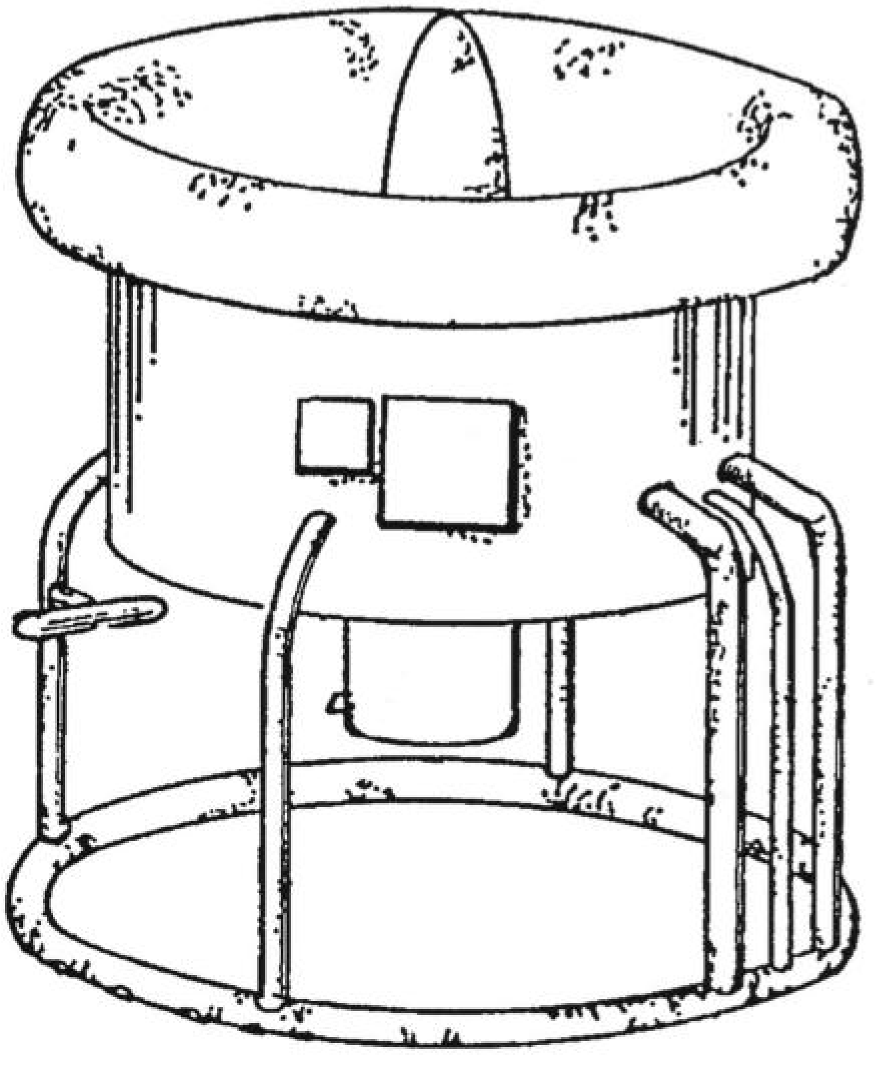




Top: **These drawings show the appearance of the Moller XM-3.** Moller International

Above: **Bearing some similarities to the Sikorsky Cypher I, this design for a ducted fan UAV was produced in 1987 by Paul Moller.** Moller International





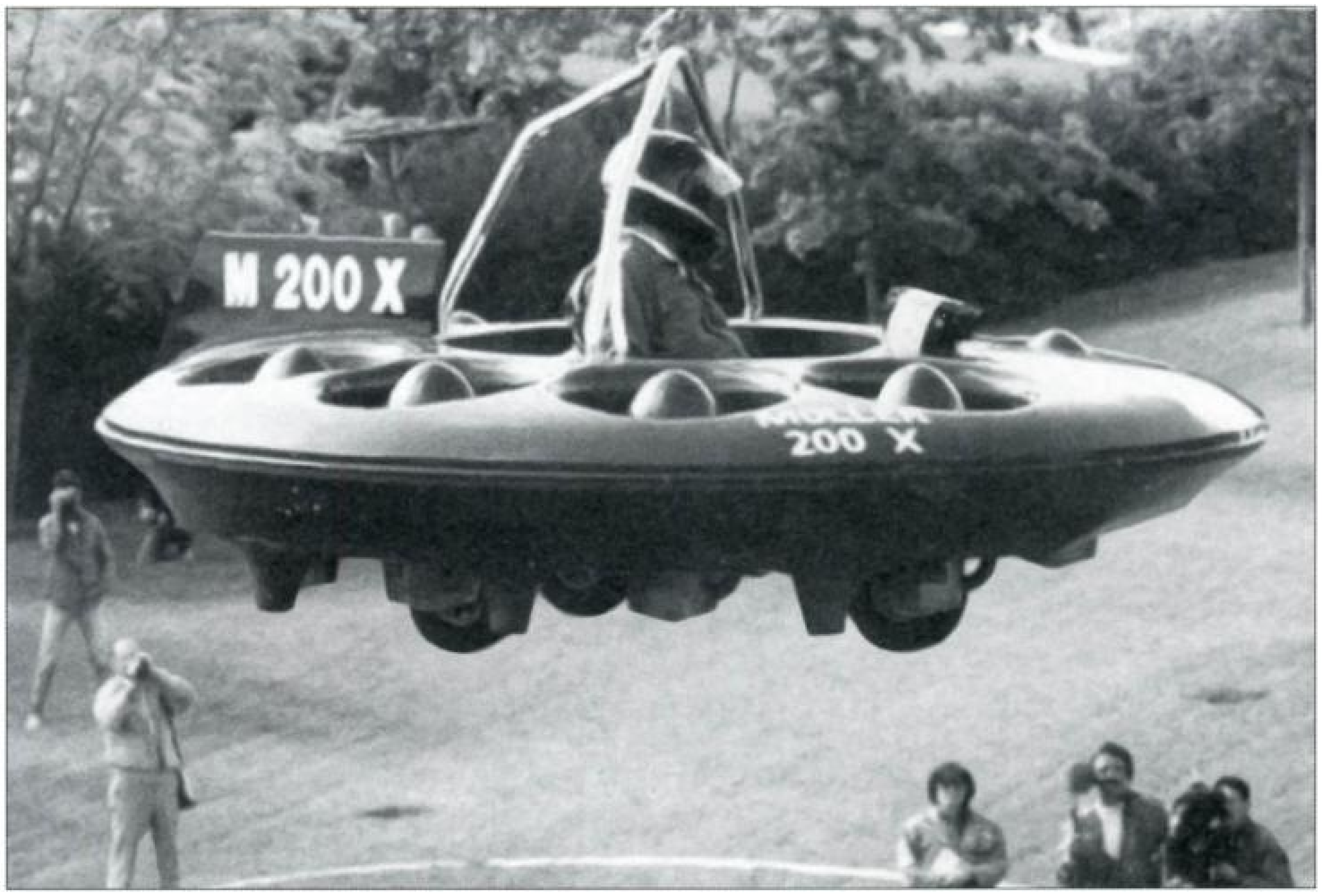
Top: **These is an early drawing for the Moller XM-4, which underwent a number of design revisions, but failed to move out of ground effect and attain flight.** Moller International

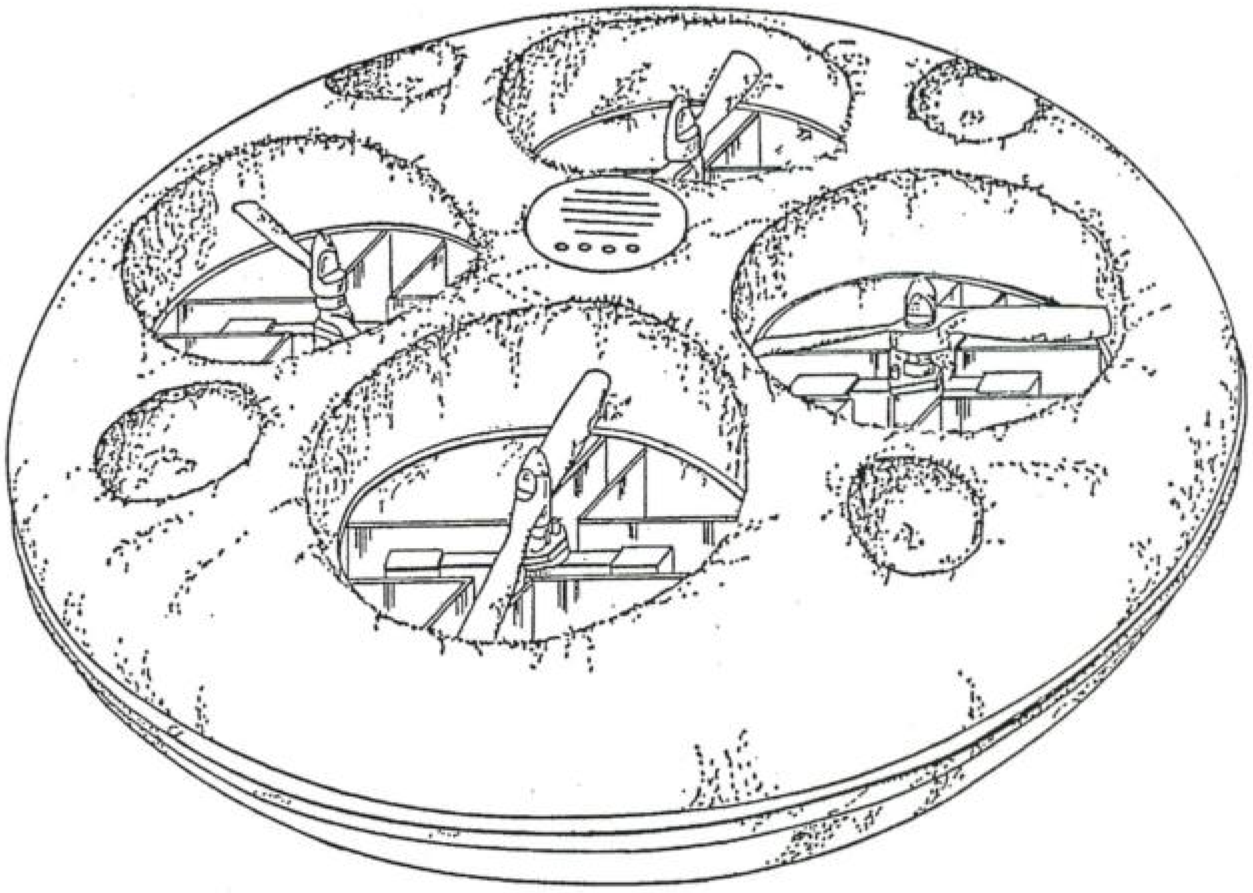
Above: **One of several small ducted fan UAV designs undertaken by Paul Moller in the late 1980s.** Moller International

Moller M400 Skycar

(Production version)

Type	VTOL Utility Vehicle
Accommodation	Four
Propulsion	Four ducted fan units with 8 rotary multi-fuel engines
Engine power	960hp (715kW)
Noise at 500ft (152m)	65db
Cruise speed	350mph (568km/h)
Max speed	390mph (628km/h)
Rate of climb	7,150ft/min (2,179m/min)
Ceiling	30,000ft (9,144m)
Payload (with max fuel)	740 lb (336kg)
Max range (full payload)	900 miles (1,448km)
Takeoff & landing area	35ft diameter (10.67m)
Gross weight	2,400 lb (1,089kg)
Dimensions	
Length	18ft (5.49m)
Span	9ft (2.74m)
Height	6ft (1.83m)
Estimated price new (2004)	$US 1,000,000



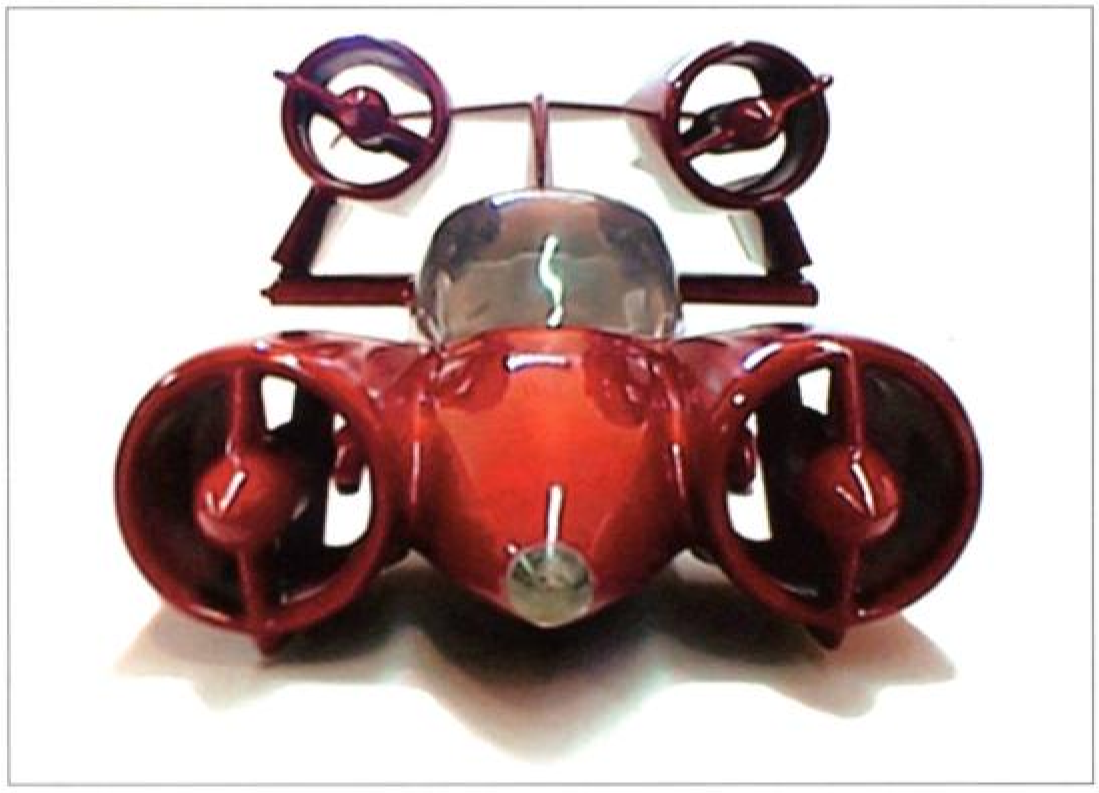


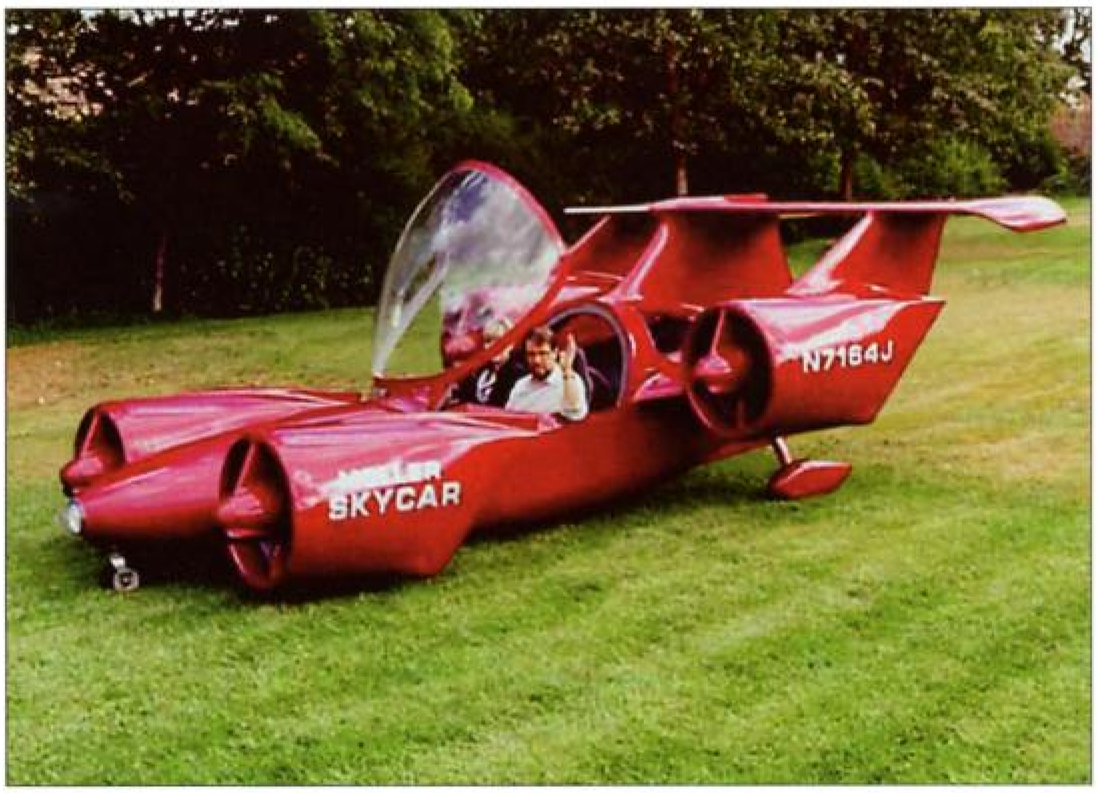
Top right: **The compact one-man Moller 200X undergoing a trial flight.** Moller International

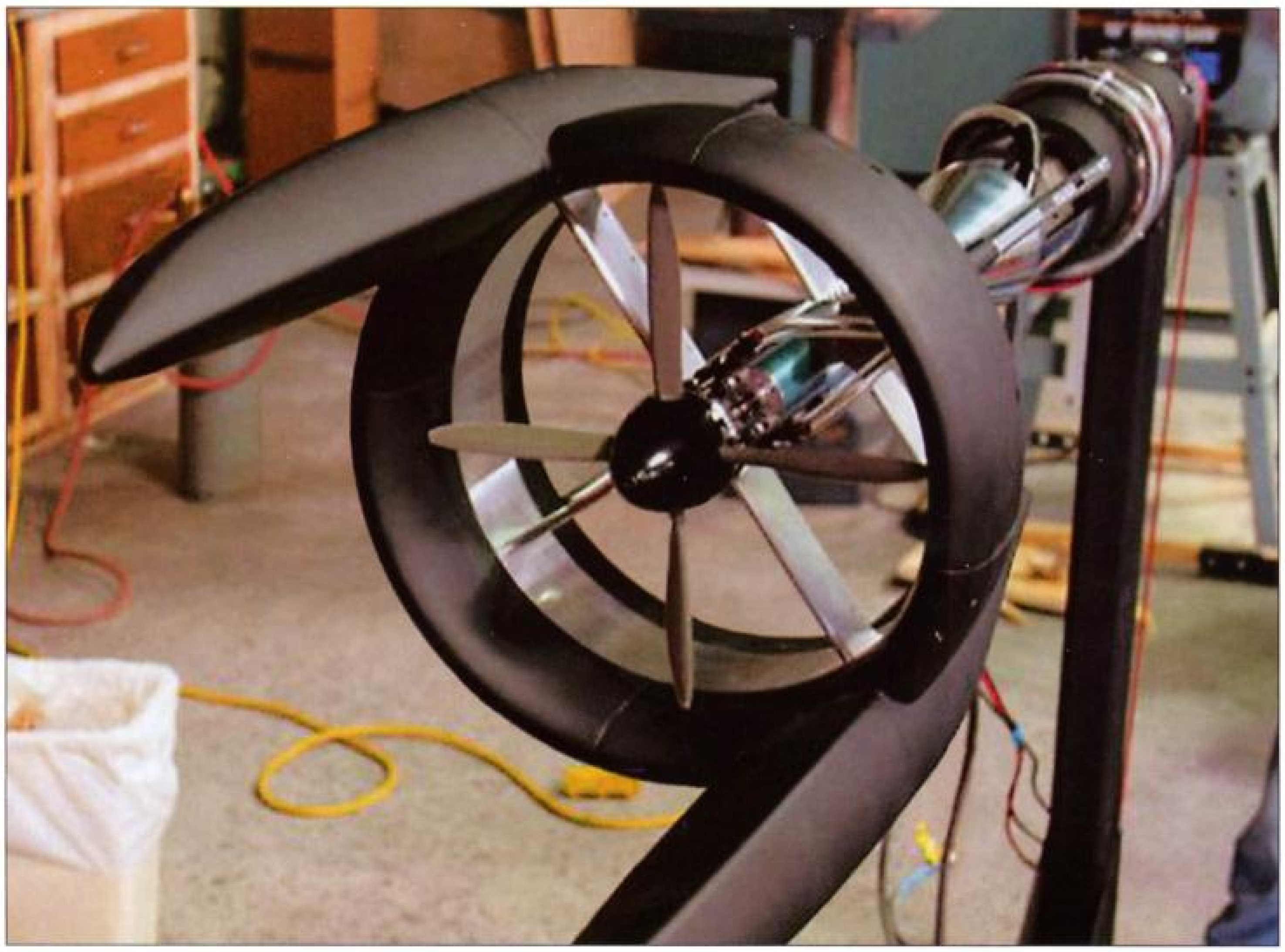
Right: **Moller concept for multi-fan UAV vehicle, circa 1989.** Moller International

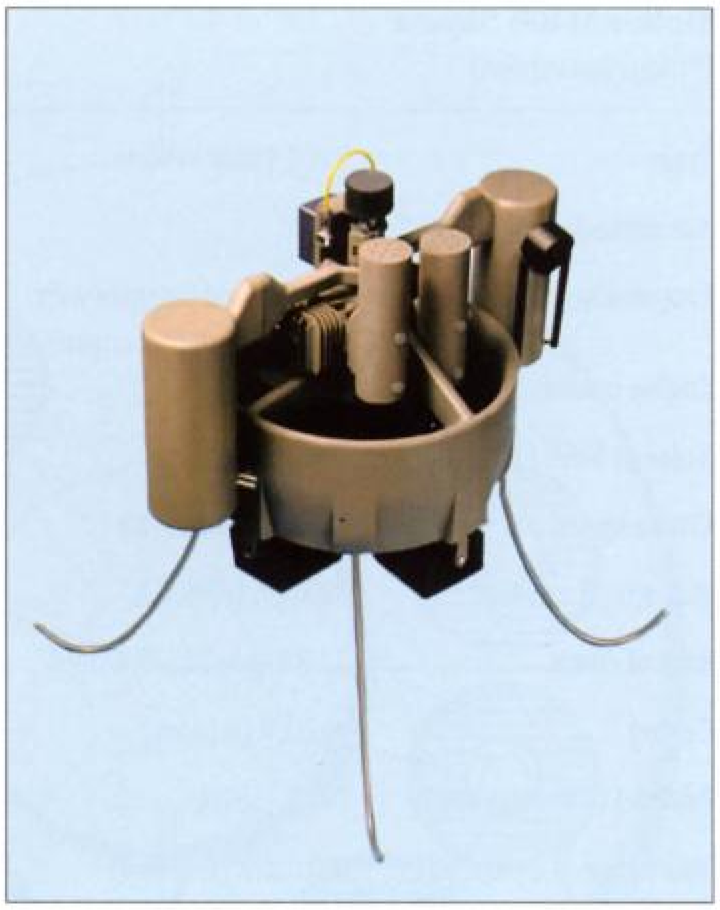
Below left: **Moller International M400 Skycar with tail unit folded for storage.** Moller International

Below right: **Moller International M400 Skycar.** Moller International





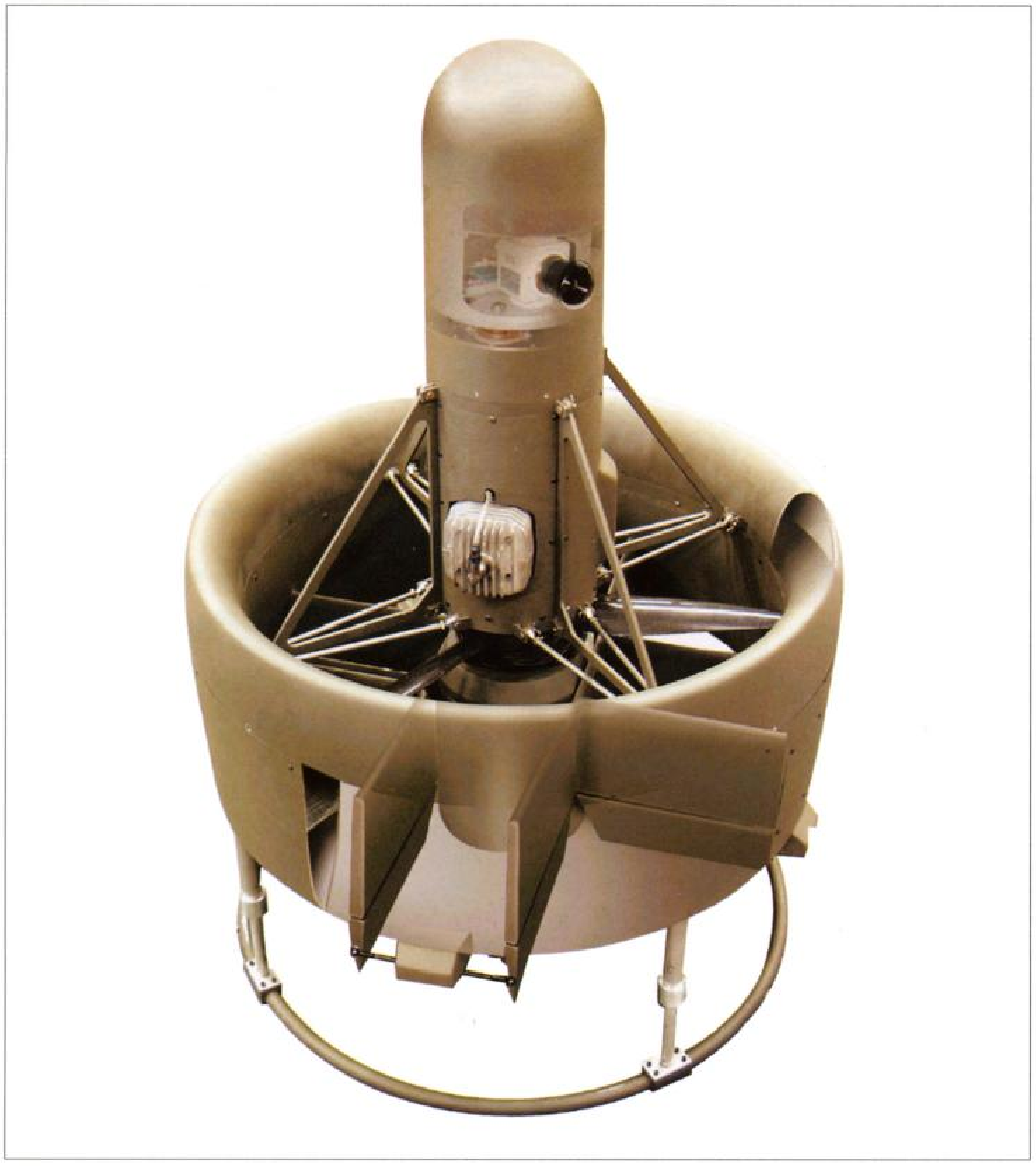




Above: **Wind tunnel test model of the Honeywell Kestrel OAV, built by engineering subcontractor Techsburg.** Techsburg

Above left: **Honeywell ducted fan Class 1 OAV prototype.** DARPA

Lower left: **Allied Aerospace iSTAR VTOL ducted-fan UAV showing camera and supports/vanes.** Allied Aerospace



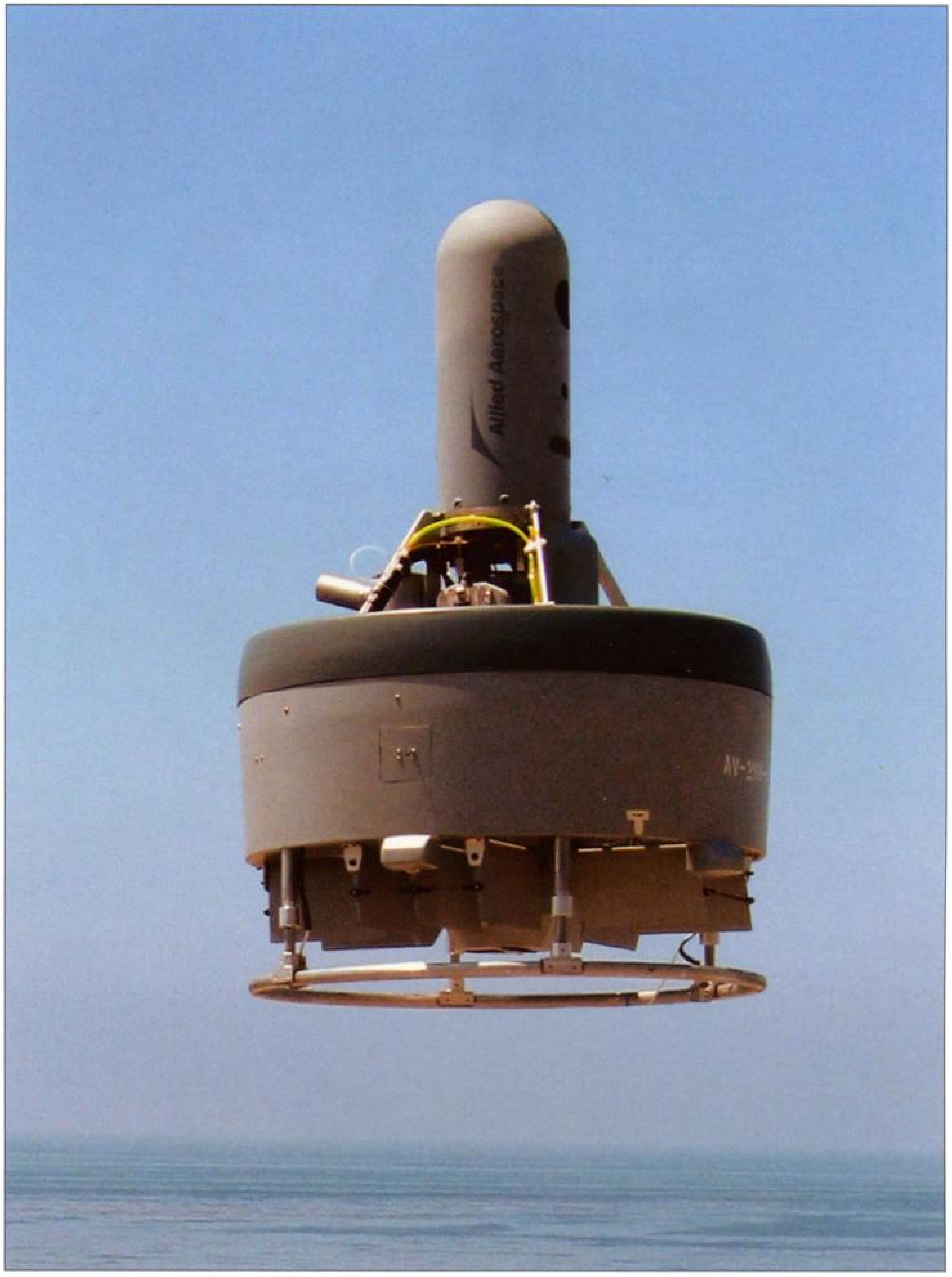
four ducted fans and is intended to have full VTOL capability, the ability to cruise at 350mph (563km/h), a ceiling of 30,000ft (9,144m) and an unrefuelled range of 900 miles (1,448km). Moller International claims to have spent $100 million developing the Skycar and, according to company reports in 2004, there were one hundred reservations for FAA-certified models. Recent estimates suggest a price tag of about $1 million per copy. However, despite all the hype surrounding this project this aircraft has yet to attain level flight, leading critics to doubt the company's honesty about the Skycar.

On 19th February 2003 the US Securities And Exchange Commission filed a settled fraud action against Paul Moller and Moller International. This was concerned with the way that approximately $5.1 million had been raised to finance Skycar from more than five hundred investors nationwide. It resulted in each defendant agreeing to a settlement, which included a permanent injunction and a civil penalty of $50,000.

Organic Platforms

During 1997 DARPA launched a $35 million project to develop various ideas for Micro Aerial Vehicles (MAV). DARPA was seeking a low-cost micro-drone with dimensions not

Allied Aerospace 29-inch iSTAR VTOL ducted-fan development vehicle. This is the 2nd prototype of this particular model. Allied Aerospace



exceeding 6in (15.2cm). This tiny machine would have an endurance of about two hours, operate with considerable autonomy and carry a video camera with a low-light capability. Aside from use during squad-level combat operations, a small craft with this capability might be carried in a pilot's survival kit to observe hostile ground forces or to act as an emergency communications relay. The project produced many interesting concepts, although the practical limits of miniaturisation with prevailing technology also became clear.

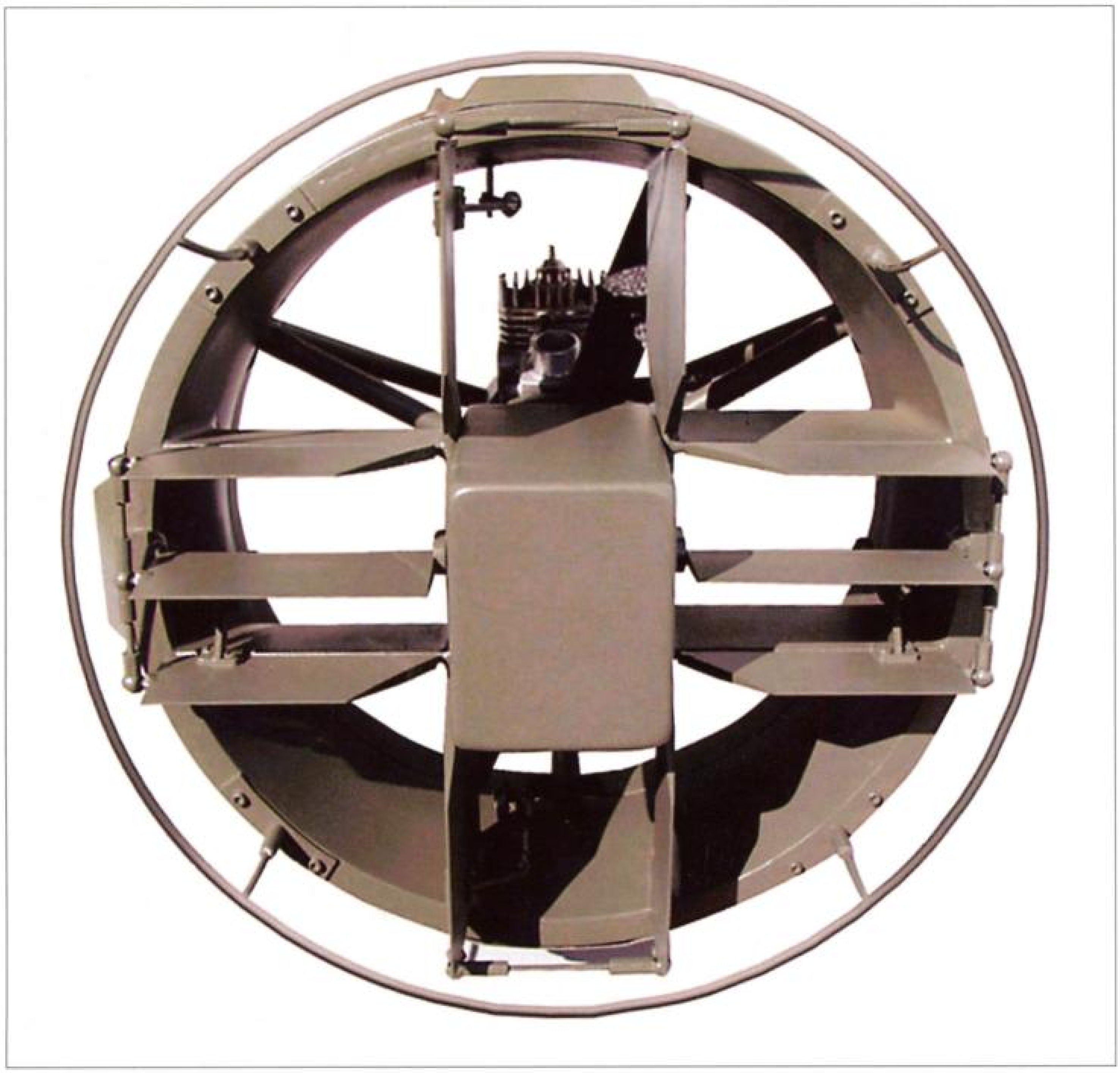
By 2001 DARPA was focusing on compact VTOL ducted fan platforms that would provide ground forces with a high-quality intelligence-gathering capability beyond visual range. In 2002 this became the Organic Air Vehicle (OAV) programme with DARPA establishing requirements for three new classes of compact VTOL platforms. They ranged from a small man-portable unit (Class I), often described as an MAV, to larger and higher-specification versions (Class II and III) transported to the operational location by a Humvee or similar-sized ground vehicle. (The term organic refers to use by the smallest combat force.)

All classes of OAV take the form of a ducted fan tail-sitter, which is capable of full VTOL, hover and normal flight. Each platform carries sensors and a control system that can link to orbital satellites, with the larger craft being better specified in terms of performance and payload capability. DARPA anticipates a high degree of automation with these vehicles, including take-off, landing and refuelling from robot ground vehicles, plus the ability (of the larger craft) to park in various locations for up to a week; in the latter situation they would operate as sentries and remote-controlled observation posts. Work on these capabilities has been part of a programme known as the Autonomous UAV Mission System (AUMS) Project, which is an officially sponsored undertaking within the Joint Robotics Program (JRP).

During the initial phase of OAV development important generic ducted-fan technologies were provided by Honeywell, which led to demonstrations being staged with a 29in (73.7cm)-diameter vehicle built by Allied Aerospace called iSTAR (Intelligence, Surveillance, Target Acquisition and Reconnaissance Equipment). To simplify the design a single fixed-pitch four-bladed rotor was chosen, with tail-mounted vanes being used for flight control (as opposed to cyclic pitch). This system provides counter-torque for the single rotor and regulates yaw, pitch and roll, with rotor rpm controlling lift. A Class I vehicle would be used for short-range forward scouting missions lasting on average fifteen minutes. Specifications include a maximum range of 3,280ft (1,000m), a maximum weight of 22 lb (9.98kg) including a 1 lb (500gm) payload, a ceiling of 7,900ft (2,408m) and a noise level limit of 75db at 23ft (7.0m).

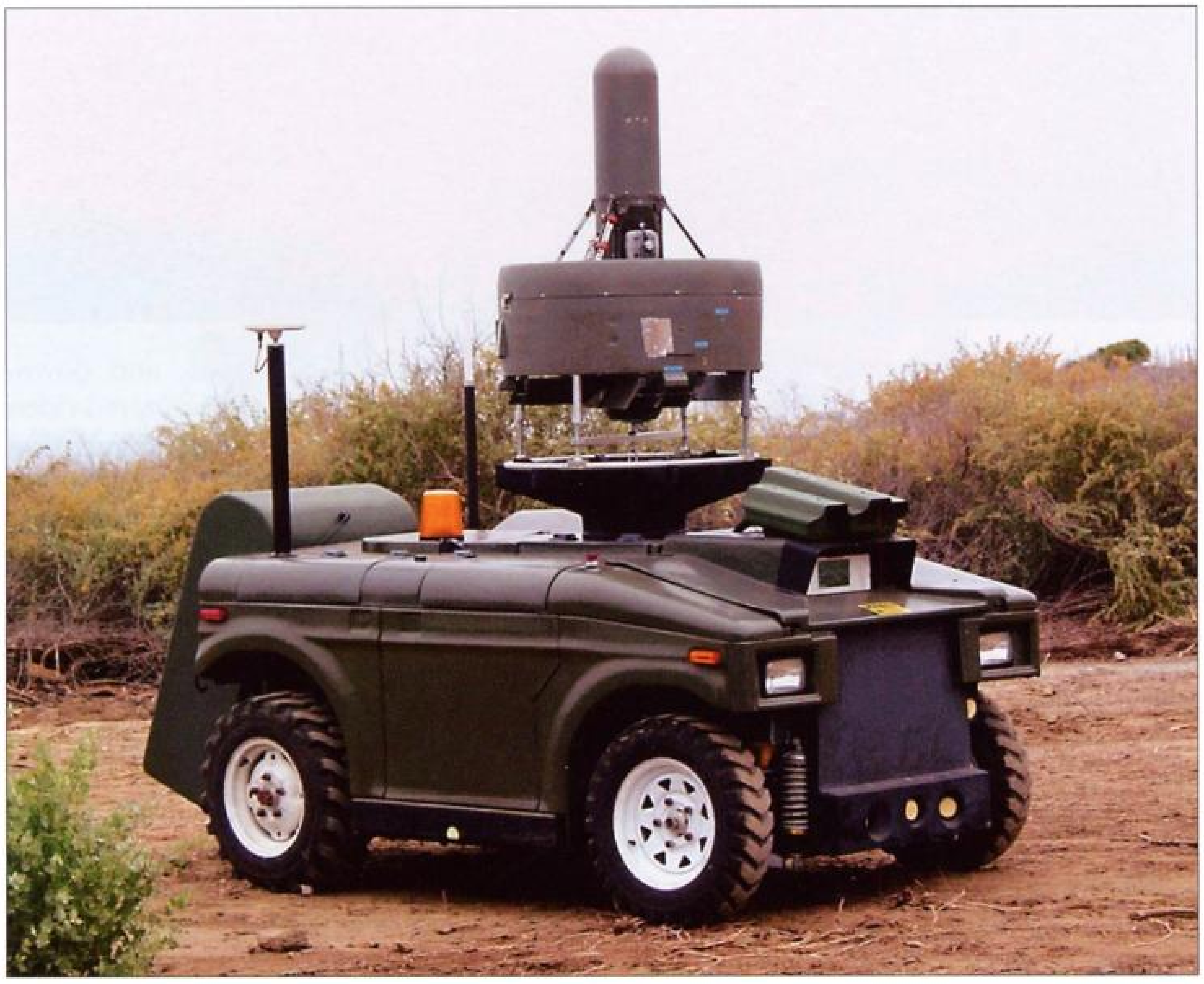
Honeywell Aerospace of Phoenix is currently responsible for the leading micro VTOL ducted fan design in these ongoing DARPA trials. This has a diameter of 13in (33.0cm) and a weight of about 12.5 lb (5.67kg). Standard equipment includes forward- and downward-looking visible-light and infra-red video cameras. The platform uses a sophisticated autonomous flight control system employing GPS navigation, and at rest it is supported by three very basic metal legs. The Honeywell craft has a maximum airspeed of 57mph (92km/h), endurance of forty minutes (depending on usage) and a range of about 1 mile (1.6km). All quoted performance figures for this design exceed the original OAV specification.

Aurora Flight Sciences have developed the relatively compact GoldenEye-50 OAV, which is a scaled-down 20 lb (9.1kg) version of their larger Class II vehicle. GoldenEye-50 flew in July 2004 and made the first transition from



Above: **Underside of the Allied Aerospace iSTAR 29-inch UAV, showing control vanes.** Allied Aerospace

Below: **Unmanned ground vehicle (UGV) used to support the Allied Aerospace iSTAR UAV.** Allied Aerospace



hover to horizontal flight during April 2005. Each test flight of the GoldenEye-50 has been fully autonomous, using the Athena Technologies GuideStar-111M flight control system. Capable of carrying a more comprehensive payload package than the small Honeywell platform, GoldenEye-50 is constructed from lightweight composite materials. It has a length of 26½in (67.3cm) and a wingspan of 4ft 7in (1.4m). Quoted endurance is one hour at a cruise speed of 62mph (100km/h).

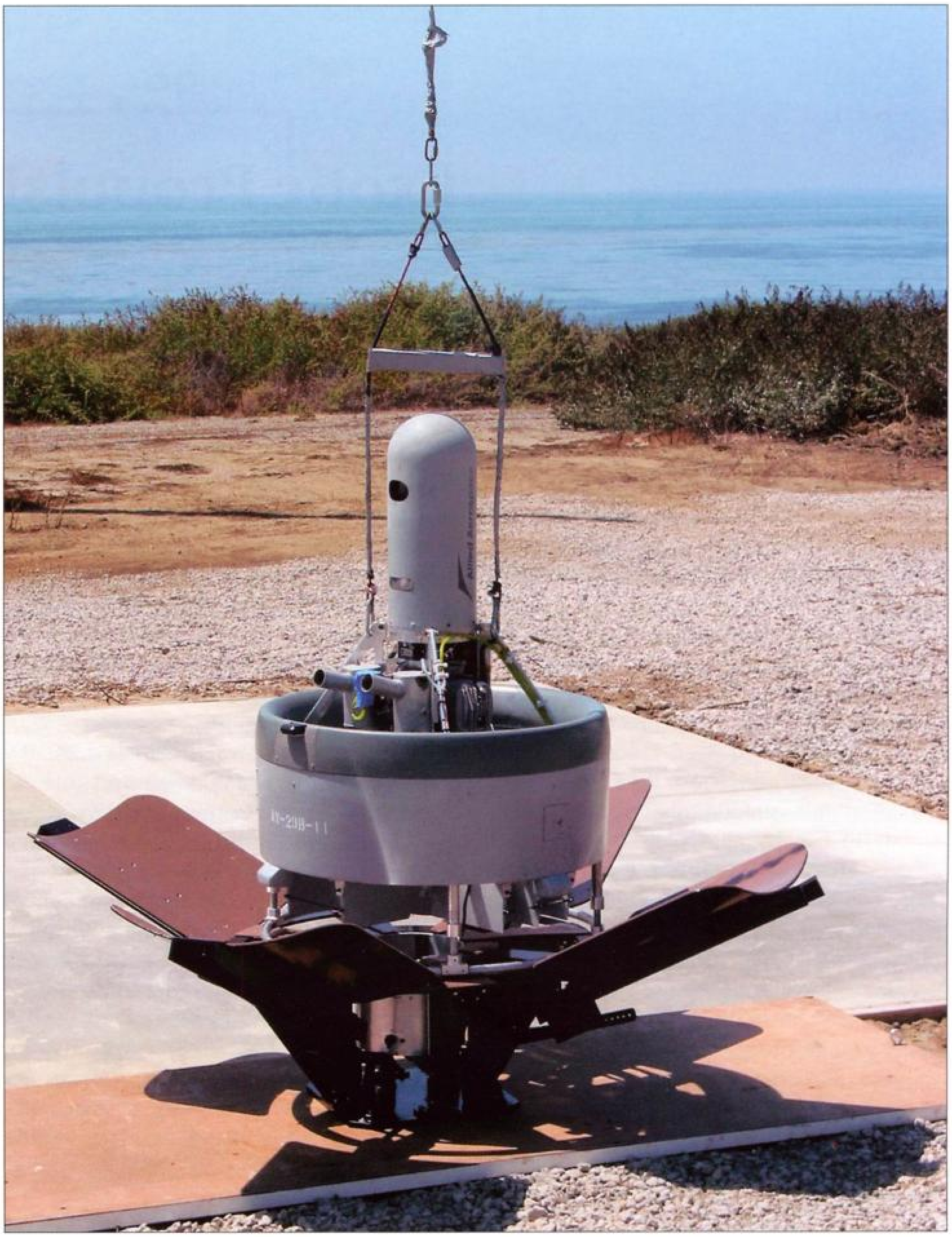
Development contracts for Class II vehicles were issued to several defence contractors on 7th December 2004, including Aurora Flight Sciences (in association with Northrop-Grumman & General Dynamics Robotic Systems), Honeywell and BAE Systems. The Class II platforms can carry more substantial payloads over greater distances and operate for longer periods, although their larger size and greater weight requires more ground support. Initial requirements for Class II OAV demonstrators were: an endurance of 25 minutes, a range of about 1.24 miles (2.0km) and a maximum speed of 50mph (80km/h). They would be expected to carry a payload of 7.5 lb (3.4kg), such as video, IR, SIGINT or acoustic equipment, with transportation to the launch site normally undertaken by a Humvee or a future robot ground vehicle.

The group led by Aurora Flight Sciences (a sub-contractor for Northrop-Grumman with considerable involvement in the Global Hawk UAV programme) provided the GoldenEye UAV for evaluation as a Class II platform. This ducted fan design (initially conceived for an earlier DARPA programme) uses thrust-vectoring methods and has a full VTOL and hover capability. GoldenEye is equipped with a pivoting wing that becomes aligned with the vehicle's centreline during cruise and is at a right angle to the centreline during hover.

It employs many advanced flight control systems including collision avoidance and autonomous operation using GPS navigation. GoldenEye is largely constructed from fibreglass and graphite composites, being supported in an upright position by four tailfins fitted with integral landing gear. Propulsion is provided by a 38hp (28kw) Wankel rotary engine providing a maximum speed of 185mph (298km/h). The dimensions are: length 5ft 6in (1.68m), wingspan 10ft (3m) and duct diameter 3ft (0.91m). Empty, GoldenEye weighs 105 lb (47.6kg) and, fully fuelled with a sensor package, this can rise to 150 lb (68.0kg).

The Honeywell platform evolved from the original 29in (73.7cm) diameter iSTAR demonstrator. Like the GoldenEye, this vehicle would carry a comprehensive multi-spectral sensor package, laser rangefinder/designator and optional equipment for NBC hazards and mine detection. The payload and fuel is housed in a pair of twin pods on either side of the duct.

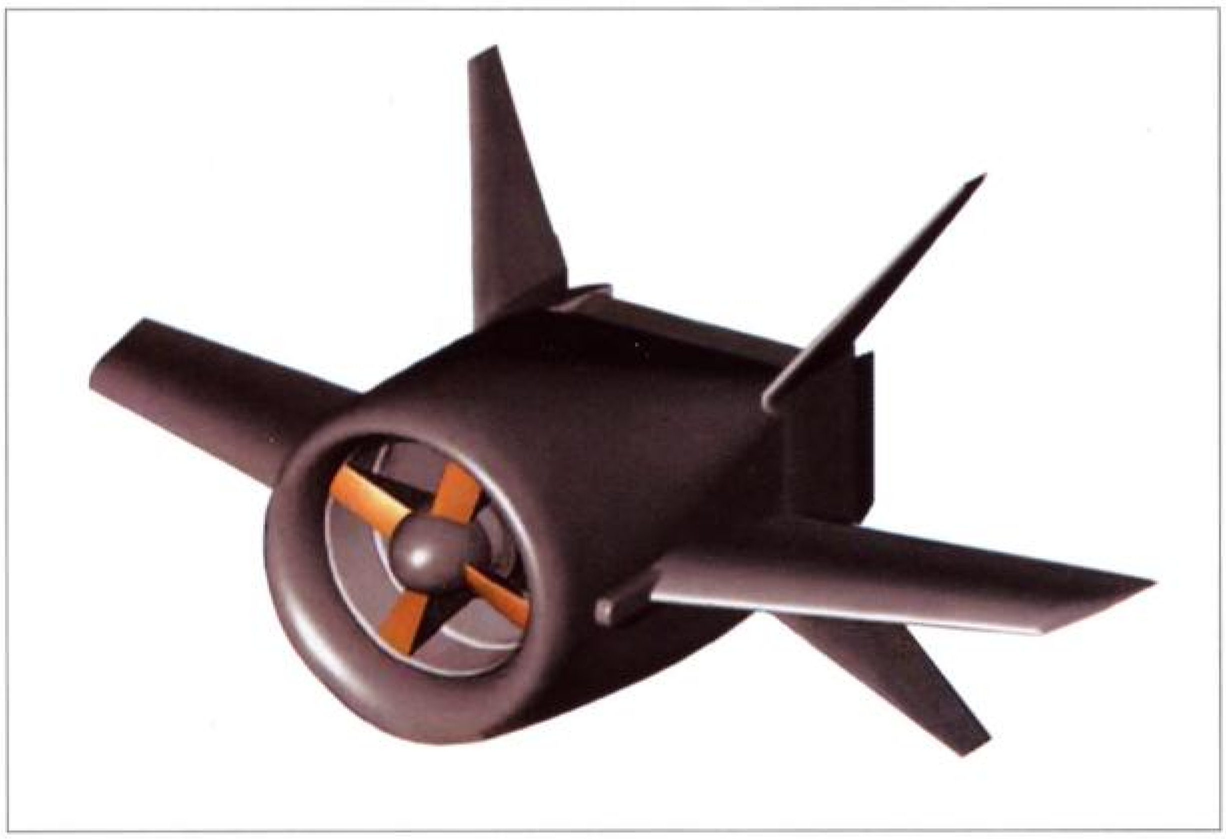
BAE Systems Platform Solutions were selected to provide the third ducted fan VTOL Class II vehicle and a development contract was awarded by DARPA to all three teams on 6th December 2004. By mid-2005 DARPA had completed its initial trials and the BAE Systems vehicle had been eliminated. Despite this, BAE Systems have continued to develop their OAV platform and at the present time the company has been testing a larger prototype with an external duct diameter of 34in (86.4cm) enclosing a 28in (71.1cm) fan. This company-sponsored model features removable wings and carries sensors on a pylon above the duct. Most of the other leading contractors involved in this programme have continued to develop OAV class vehicles for various defence and security applications. The winning Class II OAV is expected to enter service with the US Army in 2014. Larger Class III designs will have an even greater range and payload capability. These vehicles are intended to provide support at battalion level.

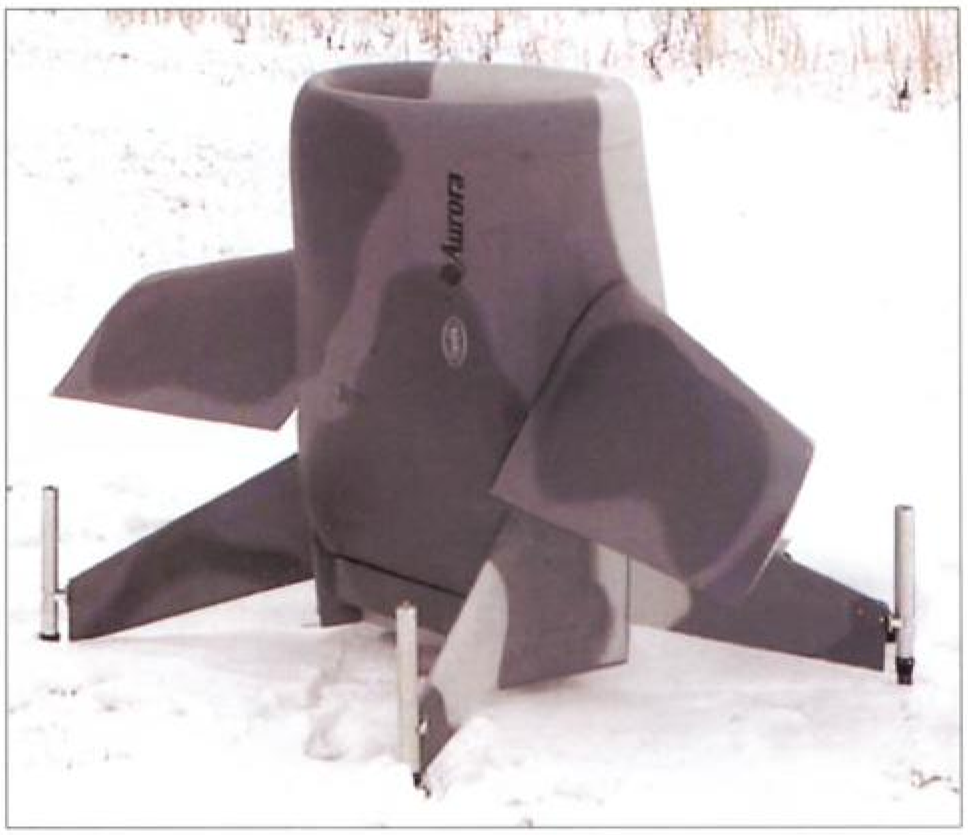


Right: **Allied Aerospace 29-inch 2nd prototype UAV undergoing trials with Recovery Pen.** Allied Aerospace

Below: **Aurora Flight Sciences artwork for GoldenEye OAV vehicle.** DARPA

Below right: **Aurora Flight Sciences GoldenEye OAV. The name was apparently inspired by the James Bond film with the same title.** DARPA





Chapter Nine

Exotic Propulsion Systems

Unusual propulsive technologies that include gravity reduction, ionic airflow, nuclear fusion, laser ablation and the beaming of microwave energy from a fixed site are generally regarded as science fiction concepts belonging to a future era. Nevertheless, most of these ideas for advanced power systems have been studied, or have been under development, for decades, and the ideal platform to utilise them is often the lenticular or disc-shape craft.

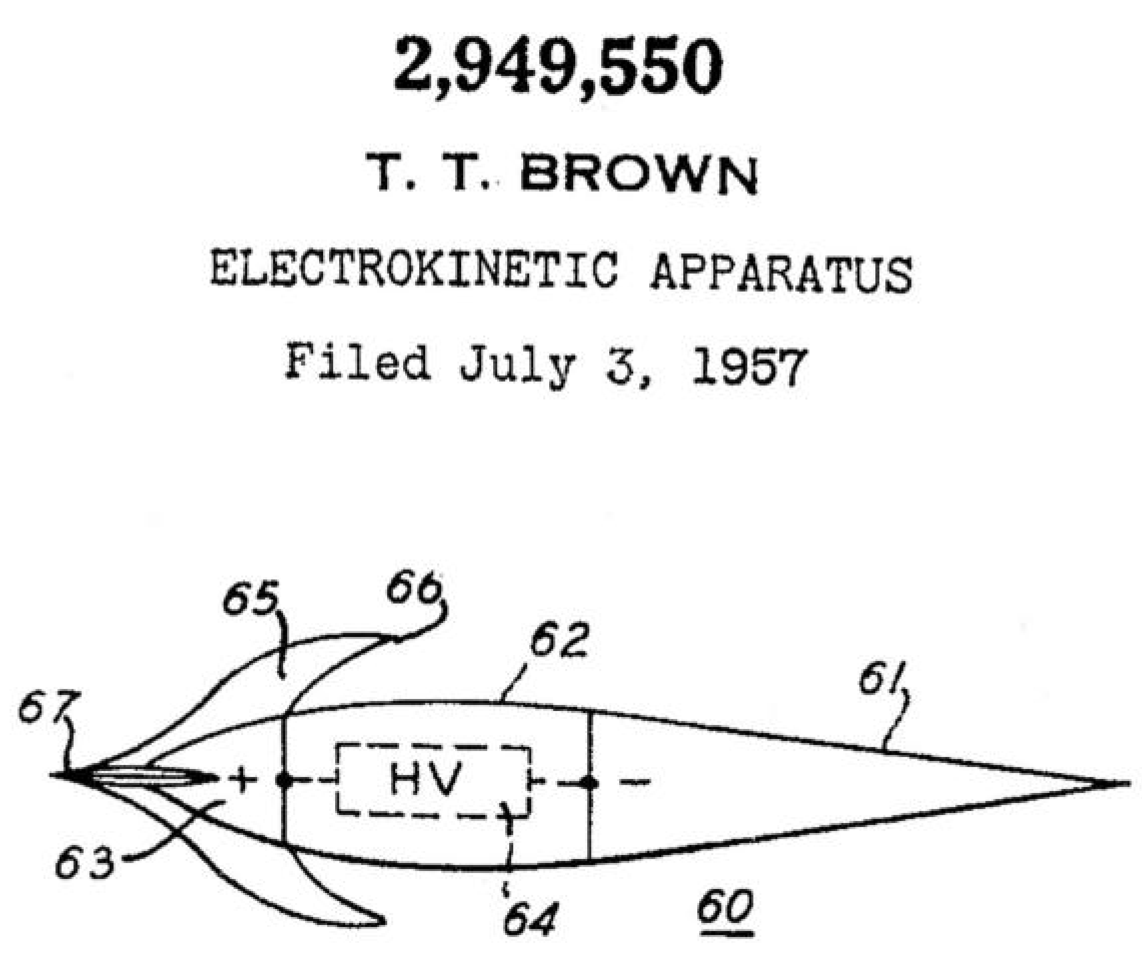
To date the US Government has spent millions of dollars researching unconventional forms of propulsion for aerospace vehicles and there is evidence of similar work taking place in other industrialised nations. As a consequence many conspiracy theorists believe this effort has yielded results, which are already in use by elite units of America's armed forces and perhaps the Russians. There can be little doubt that modest scientific advances in any of these areas would provide the military with a significant edge in any future large-scale conflict, and for this reason any technological breakthroughs would remain secret for as long as possible.

Electrogravitics

By the time he became a teenager the precocious Thomas Townsend Brown (1905-1985) had developed a serious interest in electrical engineering and was conducting all manner of small-scale experiments in a workshop behind his wealthy family's home at Zanesville, Ohio. After joining Denison University in 1923, Townsend Brown attracted the attention of Professor Paul Alfred Biefeld, who had studied physics alongside Einstein in Switzerland. Townsend Brown was soon undertaking research into the behaviour of capacitors, convinced that they were capable of generating a new unexplained force. With Biefeld's help Townsend Brown developed a complex theory, which suggested that an electrostatic charge between the two plates of a capacitor produced a small gravitational field. They finally decided to call this the Biefeld-Brown Effect and Townsend Brown spent the remainder of the 1920s studying it, while also coining the term electrogravitics as a general description for electro-gravity theory.

In 1930 Townsend Brown joined the US Navy and by the start of World War Two he was engaged in advanced minesweeping research. Heading his own research department, Lieutenant Commander Townsend Brown oversaw a staff of highly qualified scientists and had access to some of the best minds in the country, including Albert Einstein. Townsend Brown's name has often been linked to the notorious 1943 Philadelphia Experiment, which allegedly concerned an electronic form of radar invisibility. The US Navy still insists that the Philadelphia Experiment never took place, but Townsend Brown is alleged to have confirmed its existence on two separate occasions just before his death.

In 1944, after suffering a mental breakdown, Townsend Brown left the Navy and was recruited by Lockheed-Vega to undertake radar development. When the war ended Townsend Brown moved to Hawaii where he set up his own laboratory to undertake full time research into electrogravitics. At the start of the 1950s he had re-located to Cleveland and was able to fly small tethered model discs around his laboratory by means of a field-effect propulsion system. On 13th June 1952 Townsend Brown applied for a US


2,949,550

T. T. BROWN

ELECTROKINETIC APPARATUS

Filed July 3, 1957

Above: **Thomas Townsend Brown.** US Navy

Left: **Electrokinetic Apparatus patent filed by Townsend Brown in 1957. This cross-sectional drawing shows the principle features of his small flying disc demonstrator in highly simplified form.** US Patent Office

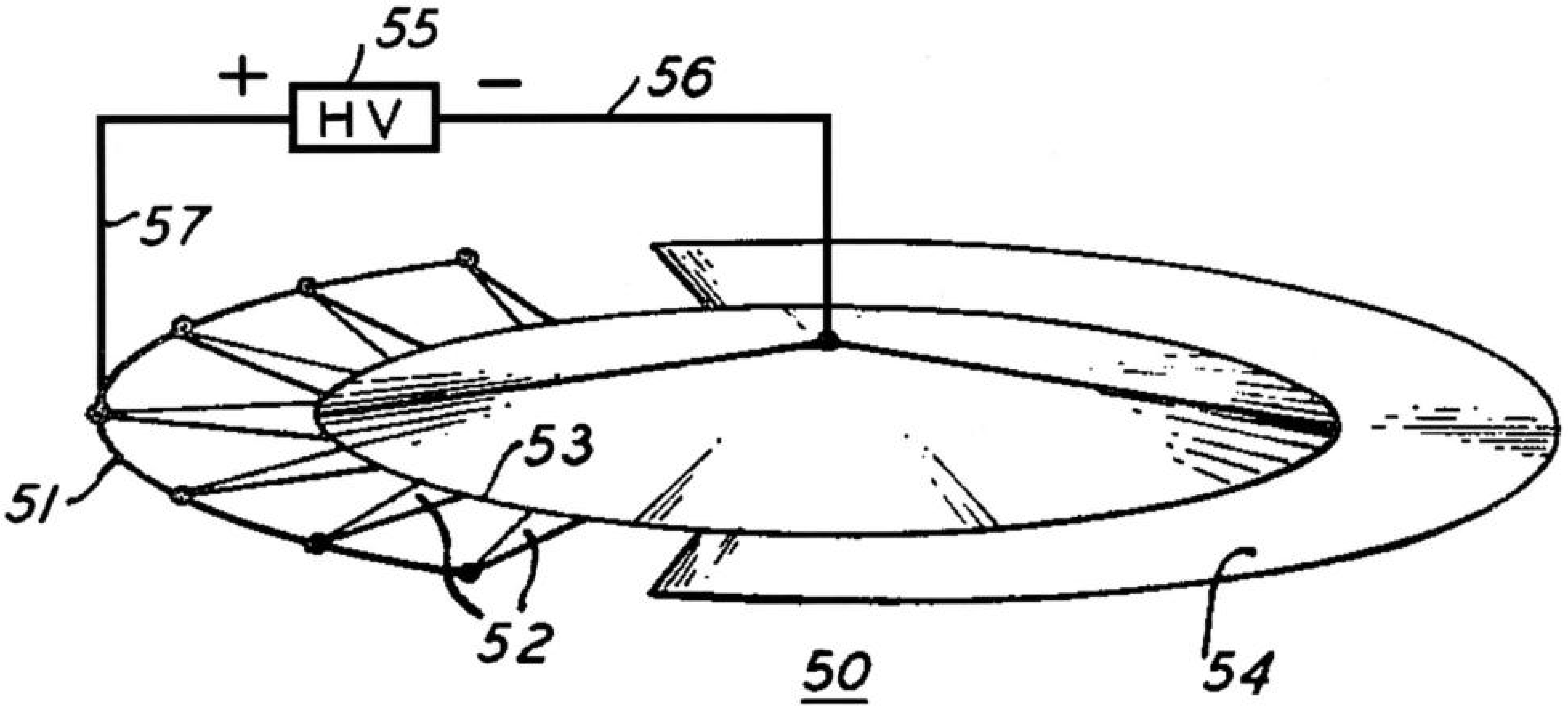


Illustration of small disc-shaped model used to demonstrate Townsend Brown's electrogravitic theory. US Patent Office

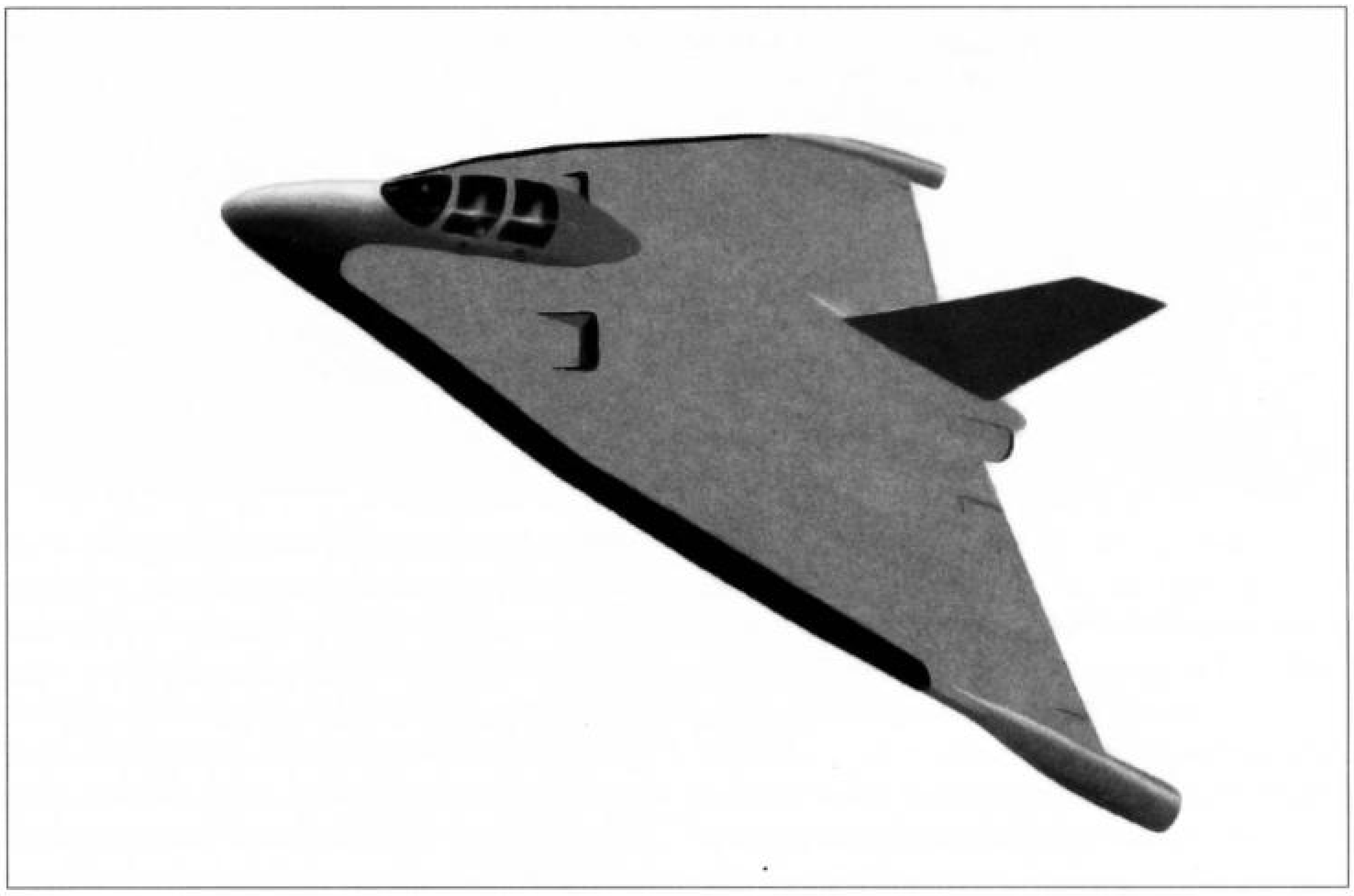
Patent (293465), describing his invention as an electrokinetic apparatus. This application was abandoned (for unknown reasons) and replaced by a second almost identical application in 1957, which was published on 16th August 1960 as Patent No 2,949,550.

The demonstrations at his Cleveland laboratory are said to have been very impressive, although some scientists suggested that the models were propelled by negative ions hitting the positive electrode and creating pressure, rather than the generation of a gravity wave. In fairness, Townsend Brown was always cautious with descriptions of his work in technical literature and often avoided discussion of gravity. As an example of this, he had the following to say about electrokinetic action: 'While the phenomenon just described has been observed and its existence confirmed by repeated experiment, the principles involved are not completely understood'. Nevertheless, after his discovery had been described as Electric Wind by several fellow scientists, Townsend Brown and his colleague Dr Mason Rose began a series of experiments with models inside a vacuum chamber. These trials seemed to conclusively prove that more was taking place than just ionic airflow.

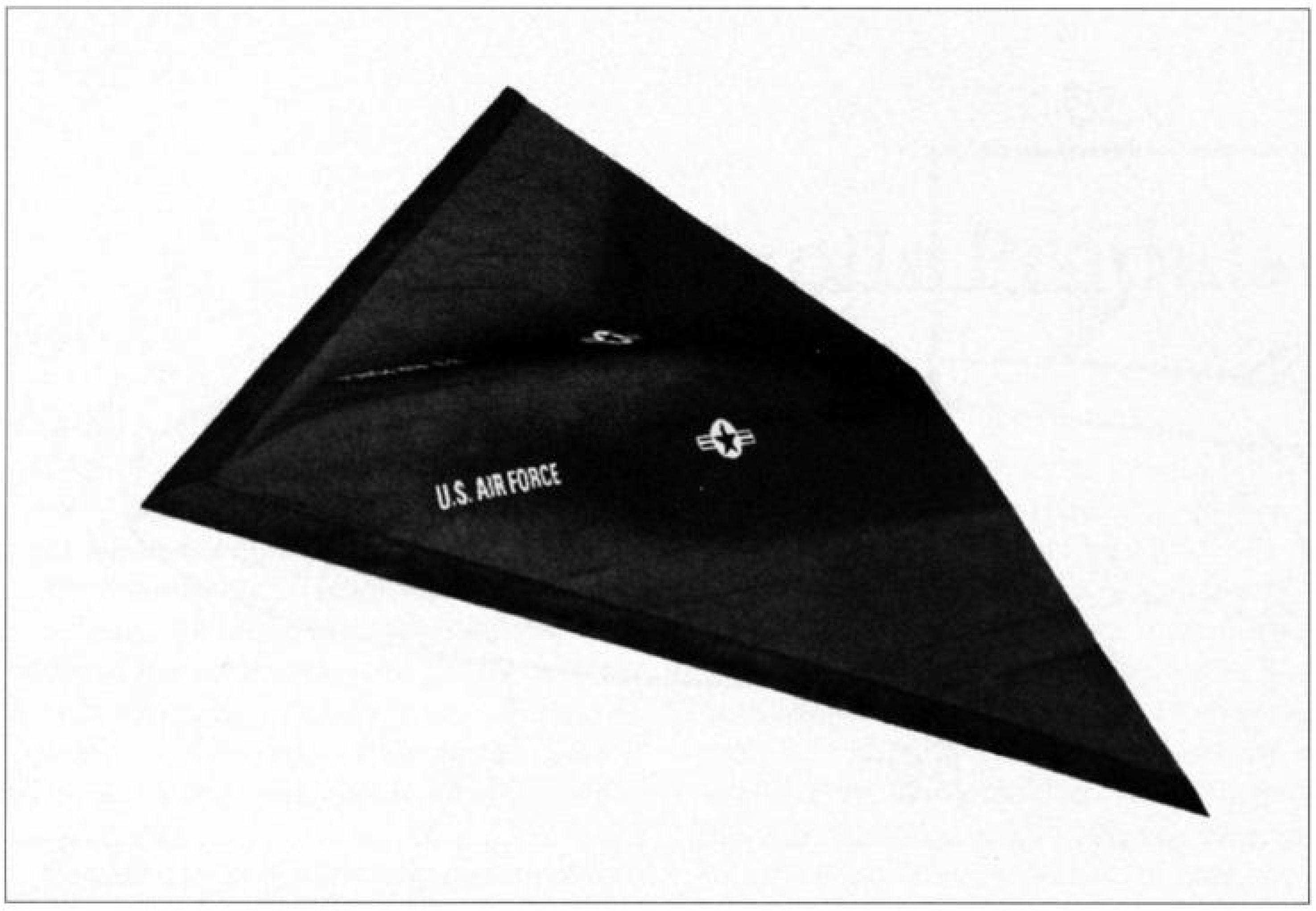
In 1953 Townsend Brown finally secured the Pentagon's attention and put on a demonstration for senior USAF officers. He used a 2ft (61.0cm)-diameter model disc attached to a 20ft (6.1m)-diameter test rig and the leading edge of his model was charged to 150,000 volts. Once in flight, the model quickly accelerated to a speed of 17ft/sec (5.2m/sec). The small disc silently whirled around the test rig, surrounded by a faintly perceptible blue-violet glow that some observers described as rather eerie. Soon after this Townsend Brown conducted a second demonstration of discs with a 3ft (91.4cm)-diameter model rotating at much higher speed around a 50ft (15m)-diameter course. USAF officials were so impressed that much of the research was immediately classified Top Secret, with aspects of Townsend Brown's work remaining under wraps until 1990 when USAF document 13-1-00034-5879 was finally released. In the meantime, Townsend Brown began to develop plans for an anti-gravity combat aircraft called Project Winterhaven.

Project Winterhaven

Townsend Brown's Winterhaven aircraft would use an electrostatic field generation system for its propulsion, which was supported by conventional turbojets. Once airborne, the leading edge would be positively charged to several million volts, while the exhaust flow became negatively charged to the same value. This would (according to



During the 1950s Avro Aircraft UK were apparently experimenting with electrogravitic technology and produced several designs for fighter aircraft similar to Winterhaven. This concept is purely speculative and is based on word of mouth information. Bill Rose



Hypothetical classified flying triangle powered by exotic field effect propulsion system. Bill Rose

Townsend Brown's theory) create a substantial gravity wave for the vehicle to ride on and he considered the disc shape ideal, because it made a large smooth dielectric area possible.

The aircraft's primary turbojet propulsion would now be operating in flame jet generation mode, running relatively cool and forming a component of the electrogravitic system. Engine thrust would no longer be responsible for pushing the aircraft forward and the relatively small fuel consumption was expected to provide intercontinental range. At the same time the engine's infra-red signature would virtually disappear, along with a reduction or perhaps total elimination of contrails. As the positively charged ion field softened the boundary layer the aircraft could easily push through the supersonic barrier, reducing the effects of turbulence and possibly eliminating a sonic boom. Townsend Brown predicted very high levels of performance for his Winterhaven design, suggesting it would be capable of Mach 3.5, with a ceiling in excess of 100,000ft (30,500m).

Although this system wasn't a full-blown science-fiction-style anti-gravity drive, it promised to be a massive step forward in aircraft propulsion technology. As a consequence, the USAF drew up plans for the long term funding of Project Winterhaven in November 1954 and they issued a string of secret research contracts to aerospace specialists. These companies included Martin, Convair, Sperry Rand, Sikorsky, Lear, Douglas, Lockheed, Bell Aircraft, Hiller and Clark Electronics. Other contractors who started their own private research programmes were Boeing, Curtiss-Wright and North American.

Although outside its normal area of interest, AT&T (the huge American Telephone and Telegraph Corporation) assigned scientists to electrogravitic research, which appears to have been secretly funded by the Pentagon. In addition, several major scientific institutions undertook USAF-sponsored electrogravitic research and these were MIT, Princeton and the CalTech Radiation Laboratory. At long last, Townsend Brown had managed to create massive interest in his cranky ideas and everyone was taking the subject very seriously.

Initial hopes for electrogravitics and Project Winterhaven were very high, but progress began to slow towards the end of 1955. By the spring of the following year there were predictions that the effort to develop anti-gravity propulsion would probably surpass the Manhattan Project (the first atomic bomb) in terms of scale and cost. This opinion soon became the official line, and then electrogravitics began to fade into the background as funding was scaled down. Townsend Brown continued to conduct electrogravitic research and founded the UFO research organisation NICAP in October 1956, but little more was heard of him or Project Winterhaven until the 1990s.

Recent document releases have shown that the US was not the only country to investigate the Biefeld-Brown Effect – for example during the mid-1950s British scientists conducted electrogravitic research. French firm SNCASO (Société National de Construction Aeronautique Sud Ouest) went one step further and employed Townsend Brown as their consultant. Several small discs were built and successfully flown in a vacuum chamber, but the project came to an abrupt halt when a company merger took place. As a consequence, Townsend Brown walked away from SNCASO in total disgust.

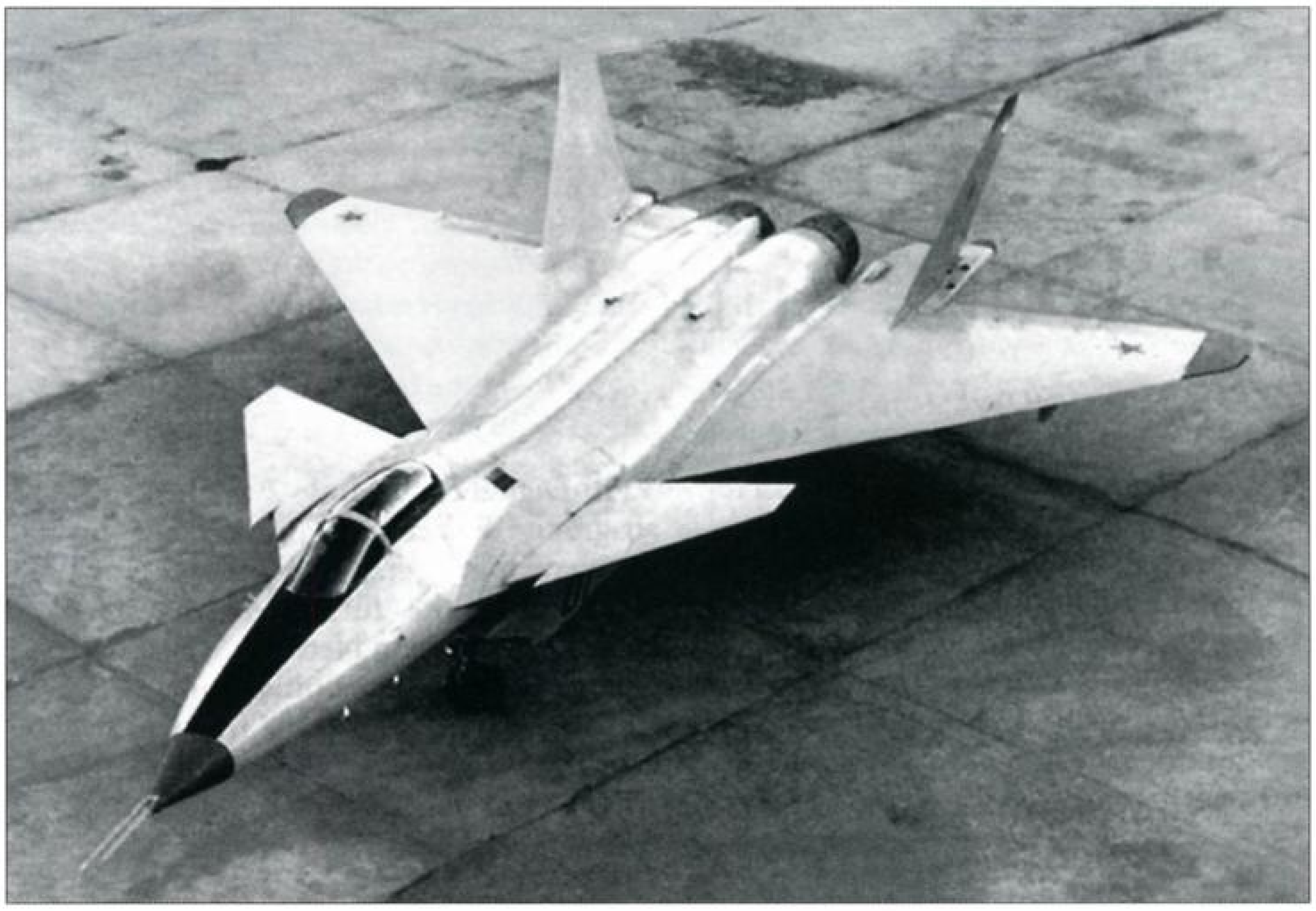
The Soviets also undertook electrogravitic research during the 1950s but relatively little is known about their early experiments. Intriguingly, a very technical report on electrogravitics surfaced in December 1956, which was written by two highly respected British scientists called Richard Worcester and John Longbent. Their paper, entitled *The Gravitics Situation*, indicated real substance to Project Winterhaven, although this analysis never reached aviation journals or the wider media at that time. Then interest in electrogravitics began to fade rapidly. Many observers felt that it had all been total nonsense, while others believed the research had moved into the black projects domain.

However, in January 1968 Northrop began to study these methods on wind tunnel models and examine the possibility of using charged fields for aerodynamic shaping and propulsion. Whether there were other US contractors undertaking this kind of research during the late 1960s remains unknown, but the USAF's Flight Dynamics Laboratory at Wright-Patterson AFB were definitely running field effect studies. In 1972 a semi-secret USAF review called Project Outgrowth identified field effect propulsion as offering the greatest potential for a future system.

In Russia during this period Anatoly Klimov began a series of classified experiments at the Moscow Radio-Technological Institute. He was looking for new ways to reduce drag and while there was no clear evidence that methods of defeating gravity were in operation, his findings made interesting reading. Along with colleagues at the Ioffe Institute in St Petersburg, Klimov claimed to have achieved drag reductions in the order of thirty per cent with ionised plasma around a small sphere in a laboratory test. By any standards this would be an impressive gain, but a small sphere is very different to a full-sized, irregularly-shaped aircraft. Although there was no guarantee that the technology could be scaled up or would work properly in the real world, Klimov's research did seem to indicate that significant performance gains were possible.

On 9th March 1992 *Aviation Week & Space Technology* carried a sensational article, which claimed that the Northrop-Grumman

Northrop B-2A Spirit stealth bomber. On 9th March 1992, *Aviation Week & Space Technology* carried an article that claimed that this aircraft utilises a secondary electrostatic propulsion system. USAF / Bill Rose

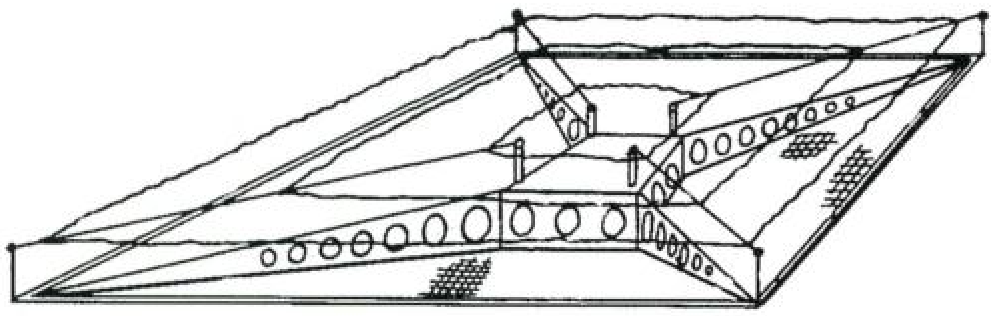


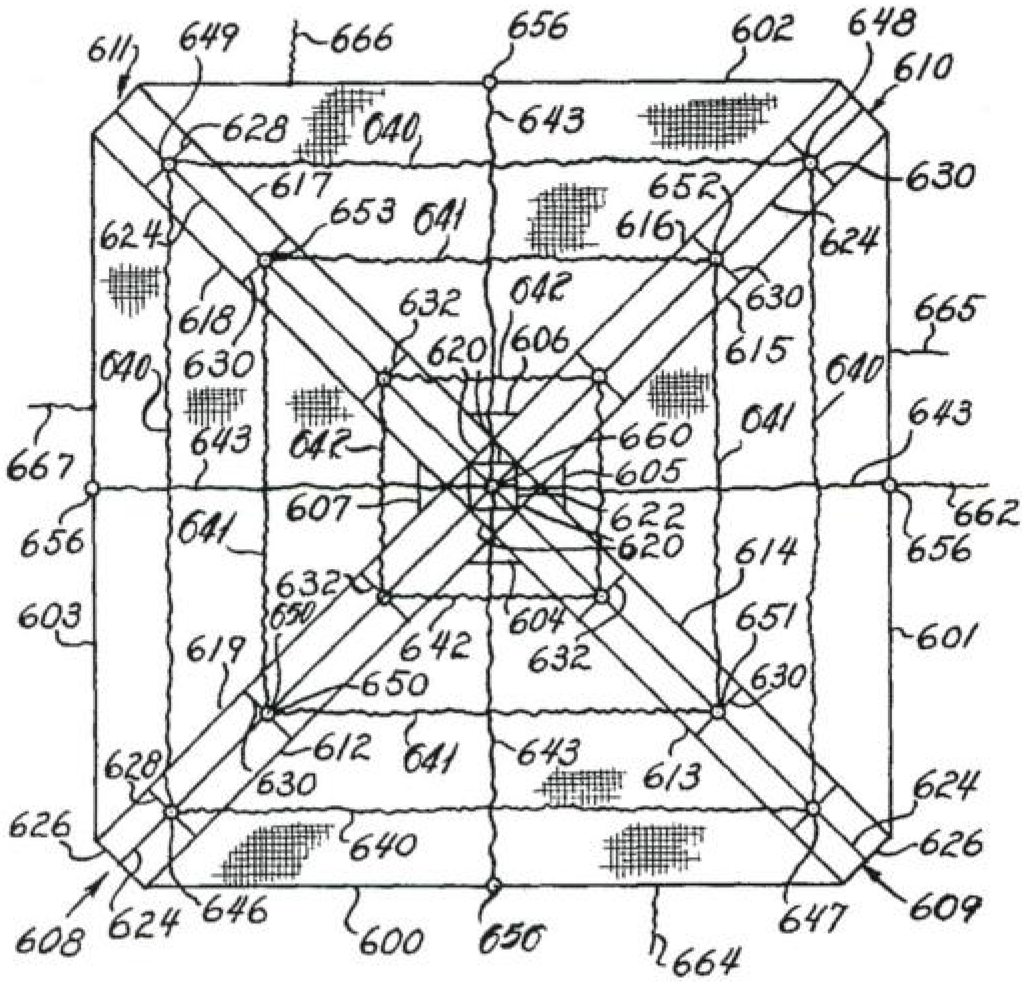
MiG Article 1.44 fifth-generation fighter. Allegedly equipped with a plasma stealth field effect system to improve performance. via Bill Rose

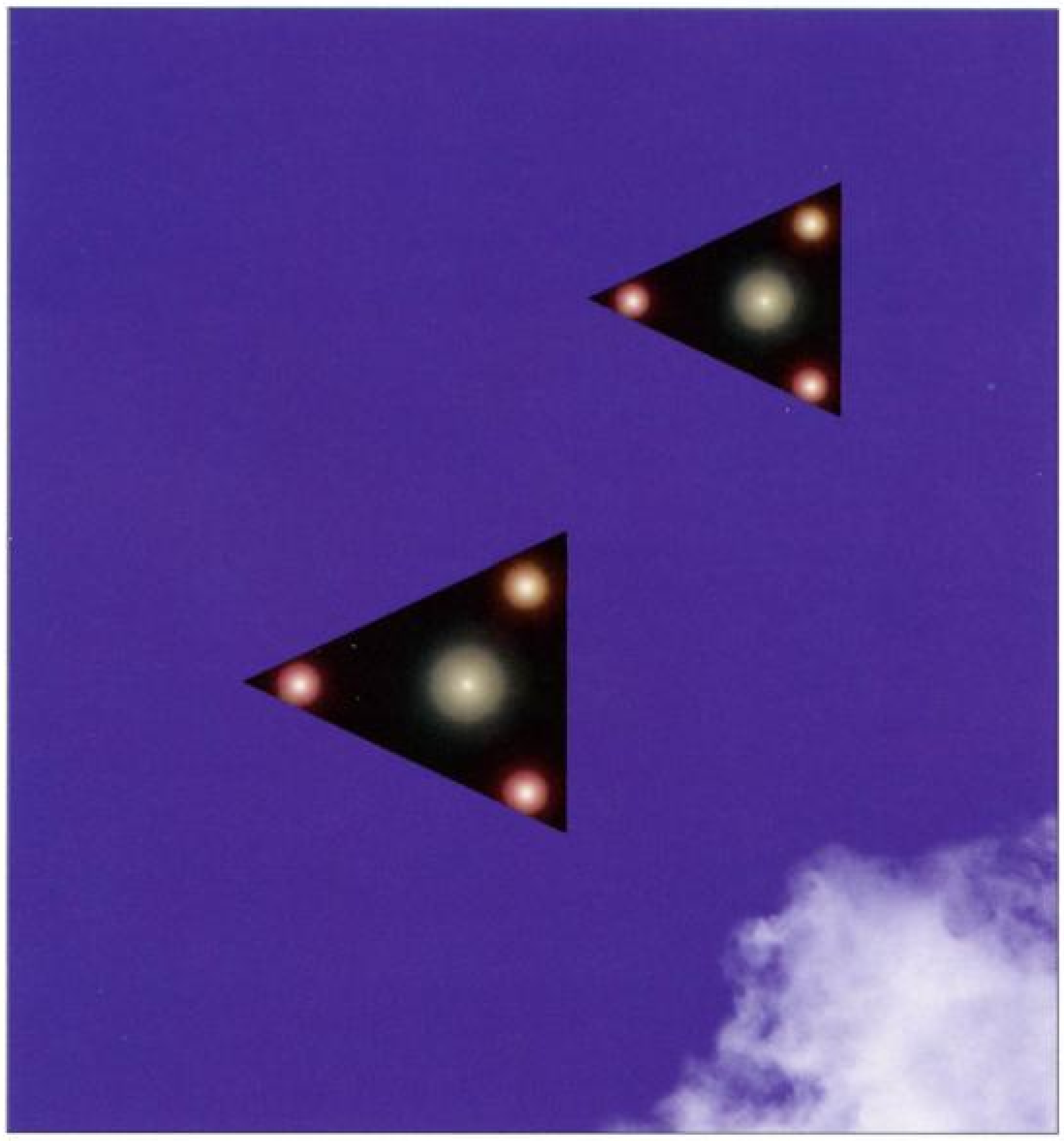
B-2A Spirit stealth bomber utilised a secondary electrostatic propulsion system. This was followed by suggestions that the field effect system was pulsed at very high frequency, perhaps in the region of 1MHz, which seemed to indicate that Townsend Brown's electrogravitic concept was far from dead. The disclosure about the B-2A had apparently been passed to *AW&ST* by a small group of disgruntled West Coast scientists who were concerned that work of this importance was being withheld by the government.

According to Dr Paul LaViolette, who has written extensively on this issue, the B-2A's sharp leading edge is energised to about 15,000,000 volts positive and the engine exhaust uses the same negative value. When this system is engaged the B-2A's four General Electric F118 turbofans switch from providing propulsive thrust to acting as flame generators that operate at temperatures not much higher than the surrounding atmosphere. In electrogravitic mode the subsonic B-2A may become capable of supersonic speed while retaining its stealthy qualities. Using this technology also apparently produces little in terms of vapour trails.

Many years ago the USAF claimed that contrails could be prevented from forming behind the B-2A by injecting highly corrosive chlorosulphonic acid into the exhaust stream. This idea was developed for the Ryan Model 147A photo-reconnaissance drone in the early 1960s, under the secret No-Con project, when it was discovered that this type of acid could be used to form very small ice crystals that would provide an almost transparent contrail. Supporters of this exotic technology mention the many convincing demonstrations given by Townsend Brown and the fact that most of the big US defence contractors







Top left: **An unusual flying platform powered by ionic airflow and patented by Major Alexander P De Seversky during the early 1960s.** US Patent Office

Left: **Technical schematic for ionic airflow powered platform designed by Major Alexander P De Seversky during the early 1960s.** US Patent Office

Above: **Hypothetical flying triangle aircraft utilising field effect propulsive technology.** Bill Rose

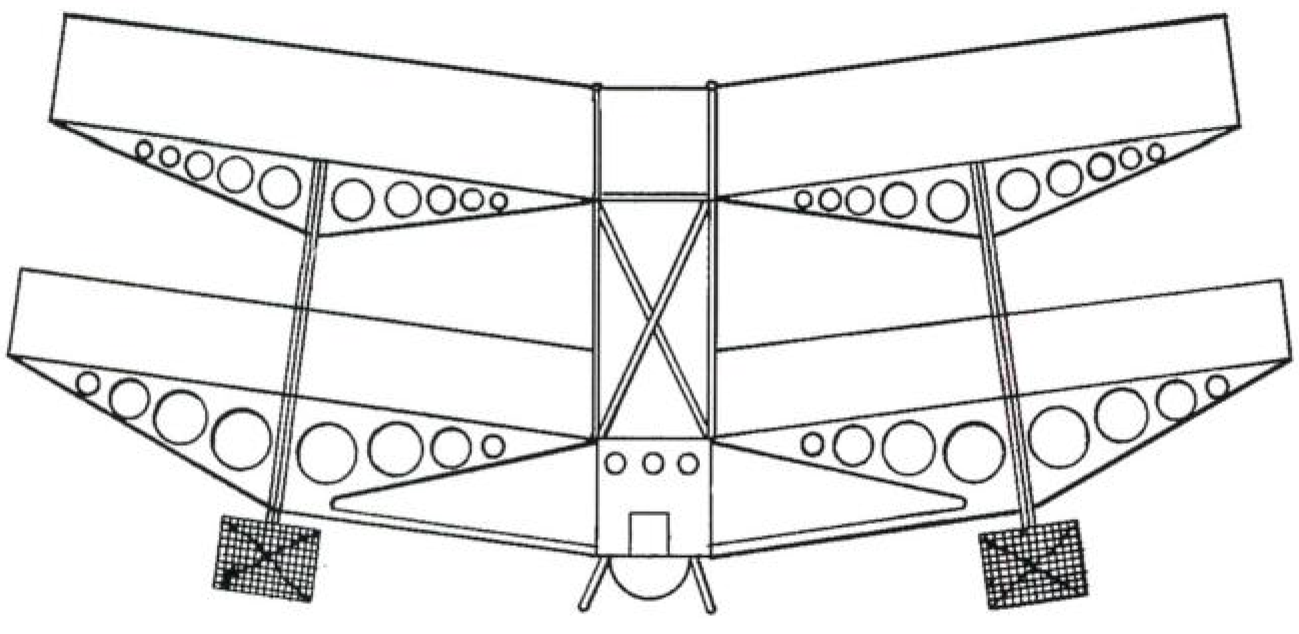
were working on the Biefeld-Brown Effect before this research disappeared from sight.

On the other hand, sceptics point to the major problem of generating sufficient electrical power to make such a system viable. They have also expressed concerns about the effects of very dense electromagnetic fields on avionics, radar and perhaps crewmembers. Another potential hazard would be flashover or arcing and it is a fact that the build-up of static electricity in aircraft through friction represented a serious problem until static dischargers were fitted. Many of these sceptics now believe that Townsend Brown simply demonstrated an elementary form of ionic propulsion and the vacuum chamber tests that followed were inconclusive.

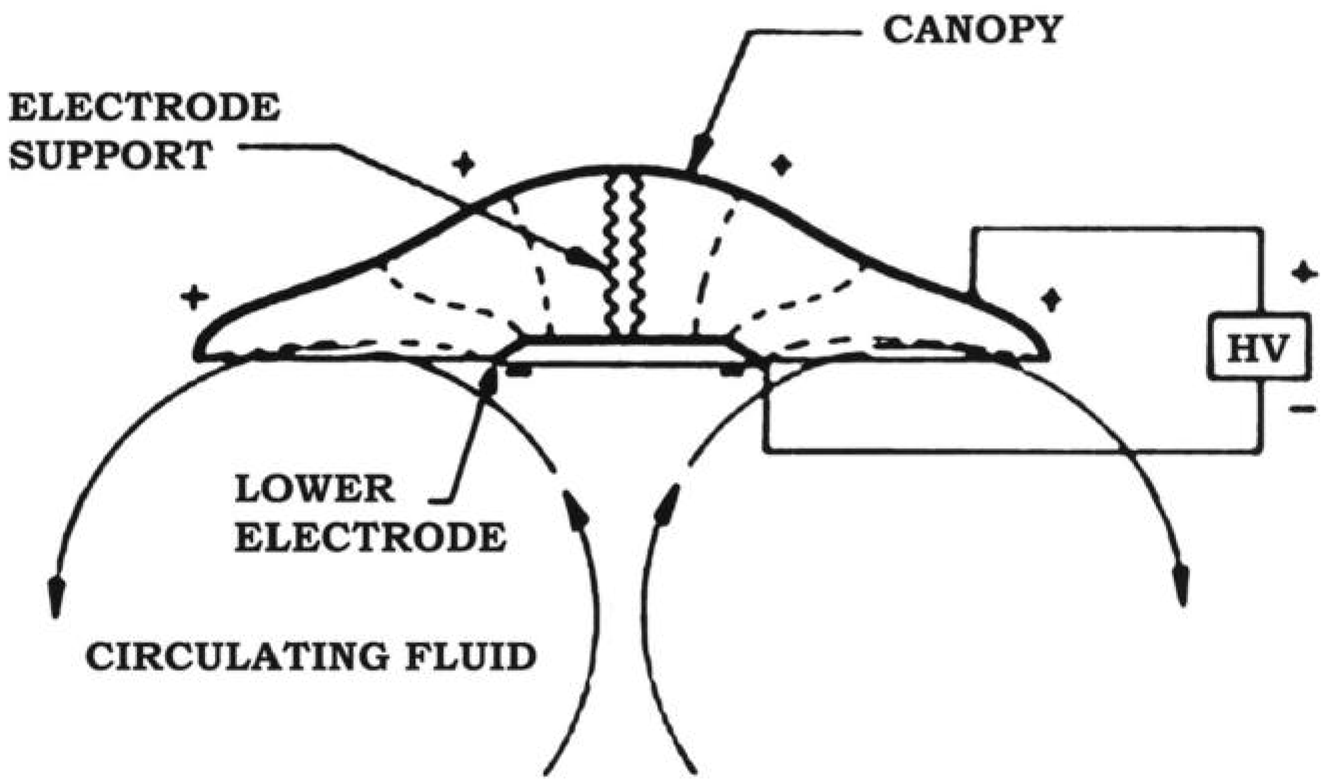
Perhaps adding some weight to the B-2A argument are claims emanating from Russia that a system called plasma stealth, based on field effect technology, has been tested on a MiG-29 and possibly also on the experimental Mikoyan Article 1.44 fifth-generation fighter. Apparently the electronics package that achieves this weighs a mere 220 lb (100kg). There would seem to be similarities between electrogravitics and ionic propulsion, which is a related technology that may have been developed within the black projects domain.

Ionic Propulsion

This system of propulsion has gained considerable credibility in recent years and it may be particularly suitable for high-altitude airships, especially those with a circular or triangular configuration. Having similarities to Townsend Brown's controversial electrogravitic ideas and eerily silent in operation, ionic field effect propulsion works by applying a high voltage to the exterior of the vehicle. This produces a negative ion field that pulls the surrounding air along its flow path.



Unusual flying platform powered by ionic airflow and patented by Major Alexander P De Seversky during the early 1960s. US Patent Office



Electrohydrodynamic (EHD) propulsion system proposed by Townsend Brown in the early 1960s. via Bill Rose

Ionic propulsion has been under development for decades and, while the idea can be traced back to Townsend Brown, the first acknowledged inventor was Major Alexander P De Seversky who filed a US patent in August 1959. By 1964 De Seversky was able to levitate and fly a small remote-controlled model aircraft that looked rather like a kite made of wire mesh. Electronatom Inc, the New York company who represented De Seversky, had high hopes for future development of this system but a lack of investment appears to have brought things to a halt within a year or so and the company disappeared without a trace.

From this time onwards some of the larger aerospace contractors started working on similar field effect propulsion projects although little information has ever reached the public domain. The upper performance limits of a full-sized vehicle can only be guessed at but there have been suggestions that an ionically propelled, saucer-shaped LTA vehicle could achieve supersonic speeds and reach an altitude in excess of 200,000ft (61,000m). It has also been said that the bigger the dielectric surface the greater the efficiency of the ionic flow system, hence the reason for building very large vehicles. Steering an LTA craft by field effect methods would work by applying different voltages to various parts of the aircraft, with a selective boost in voltage lifting or turning that particular area of the craft. By switching polarity around the periphery of the vehicle, it would be possible to manoeuvre through three dimensions with relative ease.

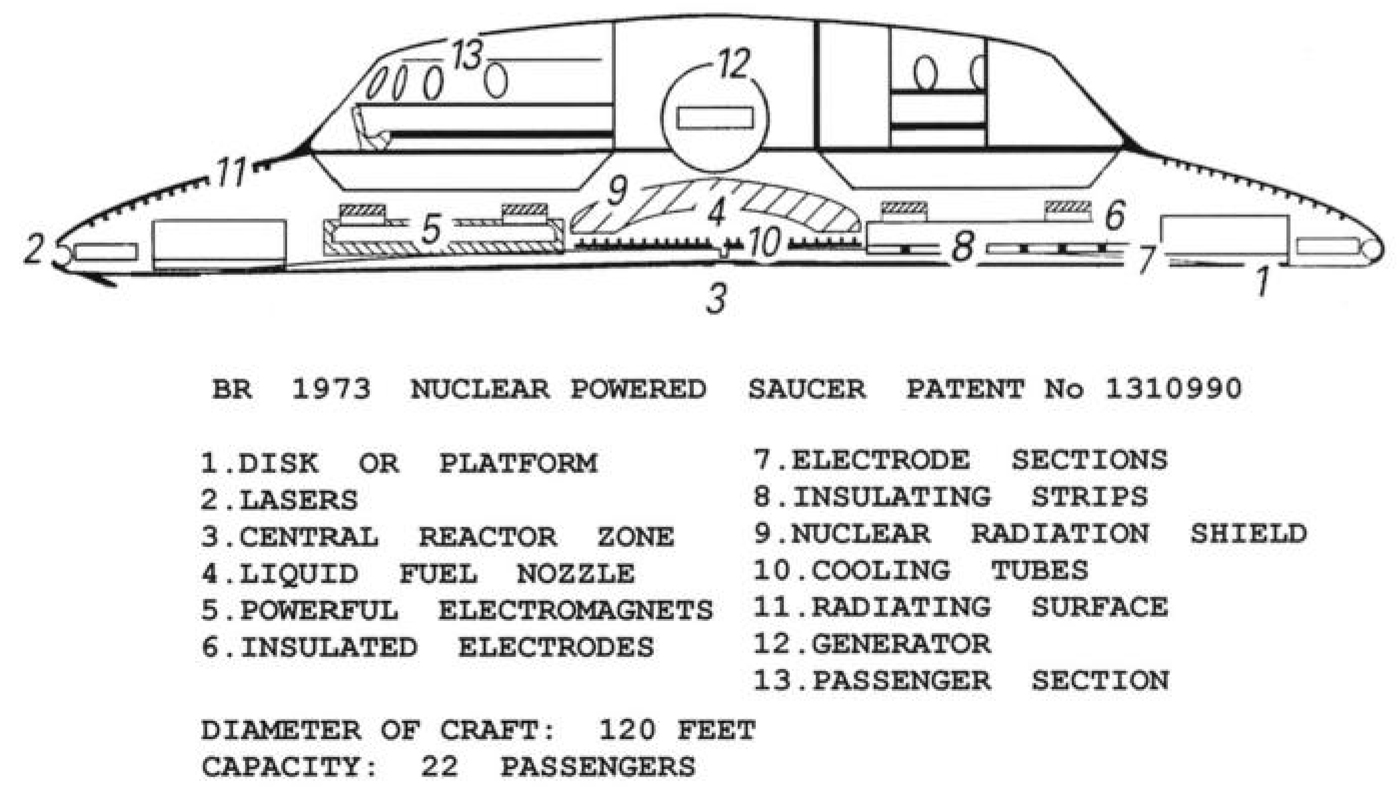
T T Brown's Plasma-Powered Saucer

By 1960 interest in electrogravitics was floundering and Thomas Townsend Brown began to consider several related methods of propulsion that promised more easily achievable results. One of these ideas was Electrohydrodynamic (EHD) propulsion and Townsend Brown envisaged a flying saucer-shaped vehicle built around a large ballistic electrode. The latter would generate a powerful toroidal plasma flow on the craft's underside and create enough pressure to produce substantial lift or forward thrust. With this plasma force beneath the vehicle resembling a whirling smoke ring, aerodynamic pressure would be exerted against the entire inner surface of the electrode (making it a form of airfoil) and the integrated pressure would act as a mechanical force.

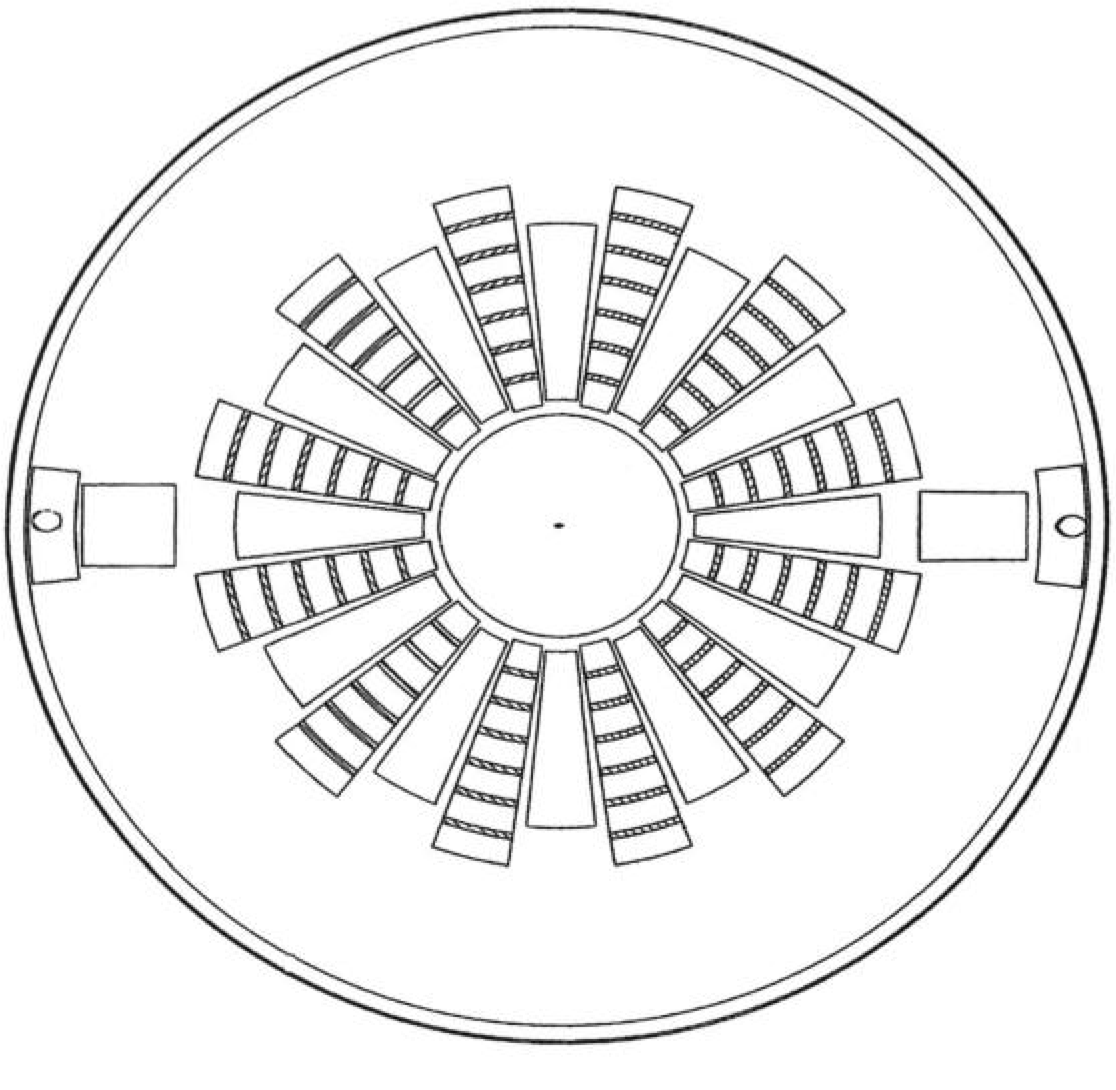
Townsend Brown went on to suggest that alkali vapour could be bled into the plasma flow to further increase its density and significantly enhance performance. However, he did little more than outline the EHD theory in his discussion paper and many issues, such as power generation and plasma containment, remained unanswered. He tested several small 3.5oz (100gm) tethered models, making them hover in mid-air and also lift additional payloads of 0.35oz (10gm). The experiments seemed to prove his theory, but Townsend Brown was unable to interest any commercial or government organisations with this idea and EHD propulsion soon faded into obscurity. Nevertheless, it seems possible that secret experiments continued within the US defence industry and the basic idea would resurface about ten years later in the most unlikely place.

The British Rail Nuclear Saucer

Few people would associate flying saucers with an organisation like British Rail (the UK's national railway network), but in late December 1970 one of its scientists completed an extraordinary design for a nuclear-powered space vehicle, which was eventually published as UK Patent No 1310990 in 1973. The designer was Charles Frederick Osmond, who might otherwise have been concerned with locomotion, trains and rolling stock. However, Osmond had become interested in the idea of using a series of lasers to ignite a liquid fuel, which was released below the craft. This would result in nuclear fusion taking place, with the controlled explosion being contained within a magnetic field.

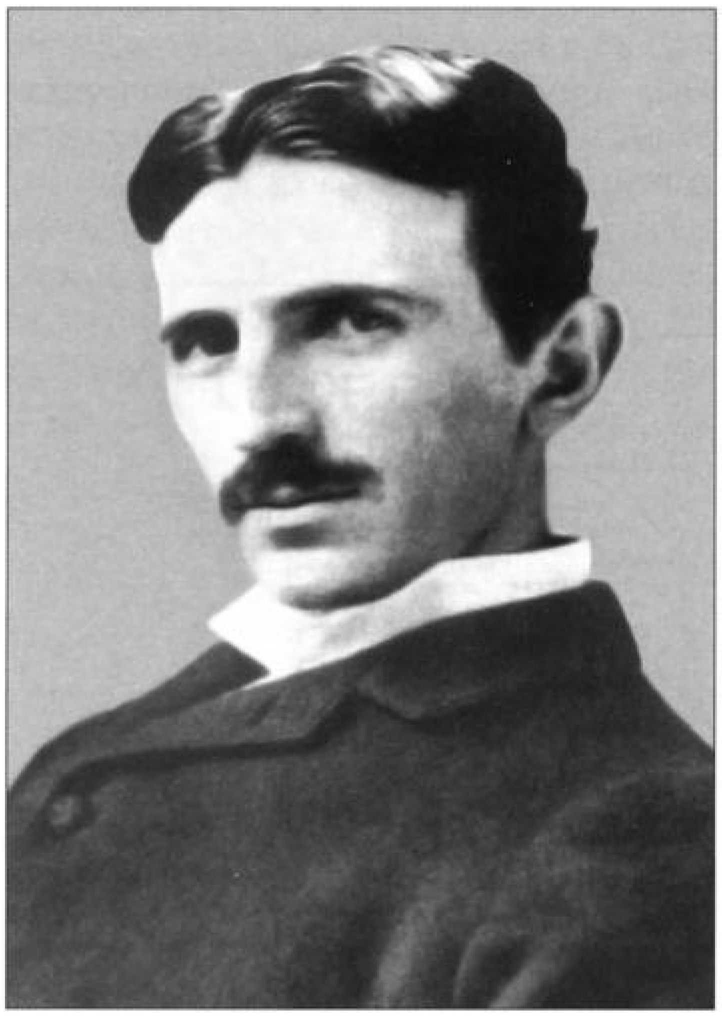


British Rail's proposed nuclear fusion-powered flying saucer. British Rail



A planform drawing of British Rail's design for a nuclear fusion-powered flying saucer. British Rail

Although the technology was unproven, Charles Osmond believed that laser-triggered fusion would be possible within a short period of time. As a consequence he applied it to the design of a flying saucer-shaped space vehicle. This utilised some elements of the EHD-powered concept proposed by Townsend Brown over a decade earlier. Osmond's design was for an almost classic-shaped flying saucer with a diameter of 120ft (36.58m), which was capable of carrying twenty-two passengers.



Dr Nikola Tesla, the Serbian-American physicist, mathematician, inventor, and electrical engineer. Bill Rose Collection

Beneath the craft was what Osmond described as a thermonuclear fusion zone, where pressurised liquid fuel would be ignited by a ring of high-energy lasers and energised by a homo-polar generator using a large spinning disc or contra-rotating discs located above the vehicle's underside. This would assist in shielding the upper cabin from radiation and was expected to provide the vehicle with some gyroscopic stability. To avoid structural vibration the lasers would operate at a pulsed rate of 1,000Hz. At the same time powerful magnetic fields would contain and direct the thermal energy beneath the vehicle, providing directional control. Presumably, the flow of fuel was expected to regulate thrust.

Osmond hoped that the magnetic containment would also help to shield the occupants of the vehicle from charged particles, although he proposed the use of heavy materials above the thermonuclear zone. Once in operation electrical energy would be drawn from the fusion reaction by a number of radially dispersed electrodes and this would power the lasers. Excess thermal energy would be carried to the upper surface of the flying disc by cooling tubes.

Throughout the available documents there is no discussion of what fuel Osmond envisaged for this vehicle, although he was probably considering liquid hydrogen. However, while the overall concept is very interesting, many of the more challenging technical aspects are not discussed in detail. Even if laser-triggered fusion had proven (or does some day prove) viable, the application to a space vehicle capable of reaching orbit or perhaps the Moon would present many scientific and engineering challenges that will remain beyond our reach for some decades to come.

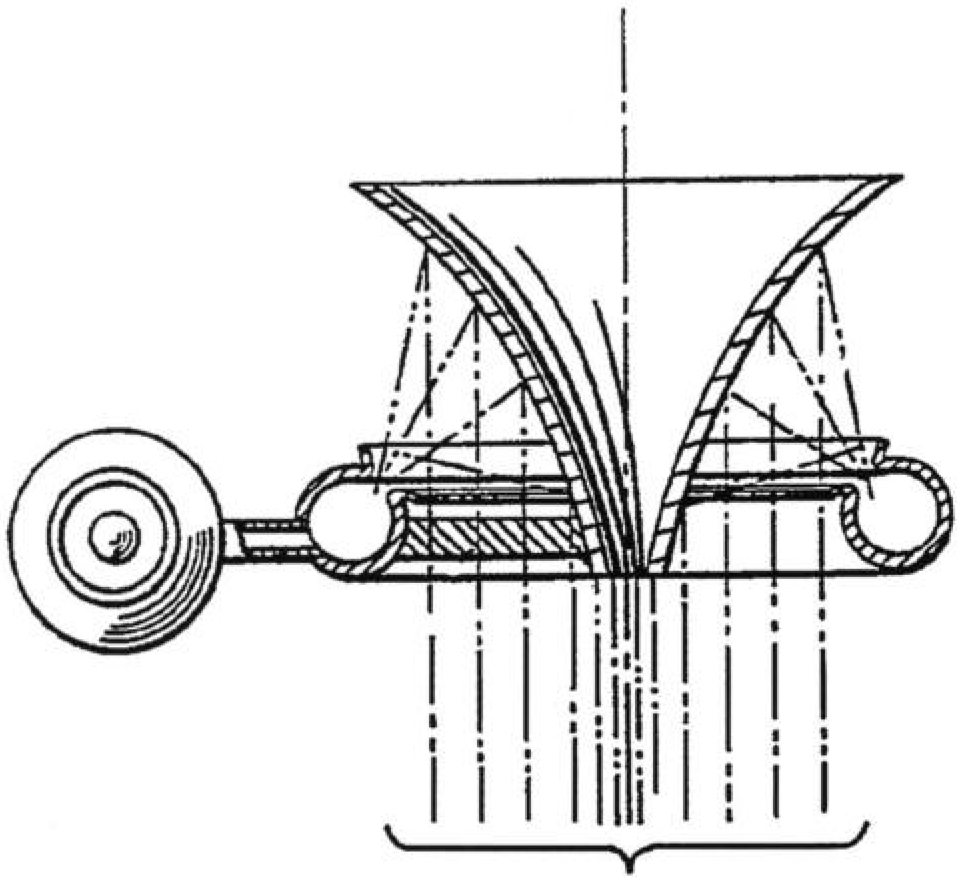
Beamed Power

The first proposals to transmit power to an aircraft were made by the scientist and inventor Nikola Tesla (1856-1943) during the early years of the last century. While discussing his earth-resonant wireless power concept during a lecture, Tesla reportedly said, 'with an industrial plant of great capacity, sufficient power can be derived in this manner to propel any kind of aerial machine. This I have always considered the best and permanent solution to the problems of flight. No fuel of any kind will be required as the propulsion will be accomplished by light electric motors operated at great speed'.

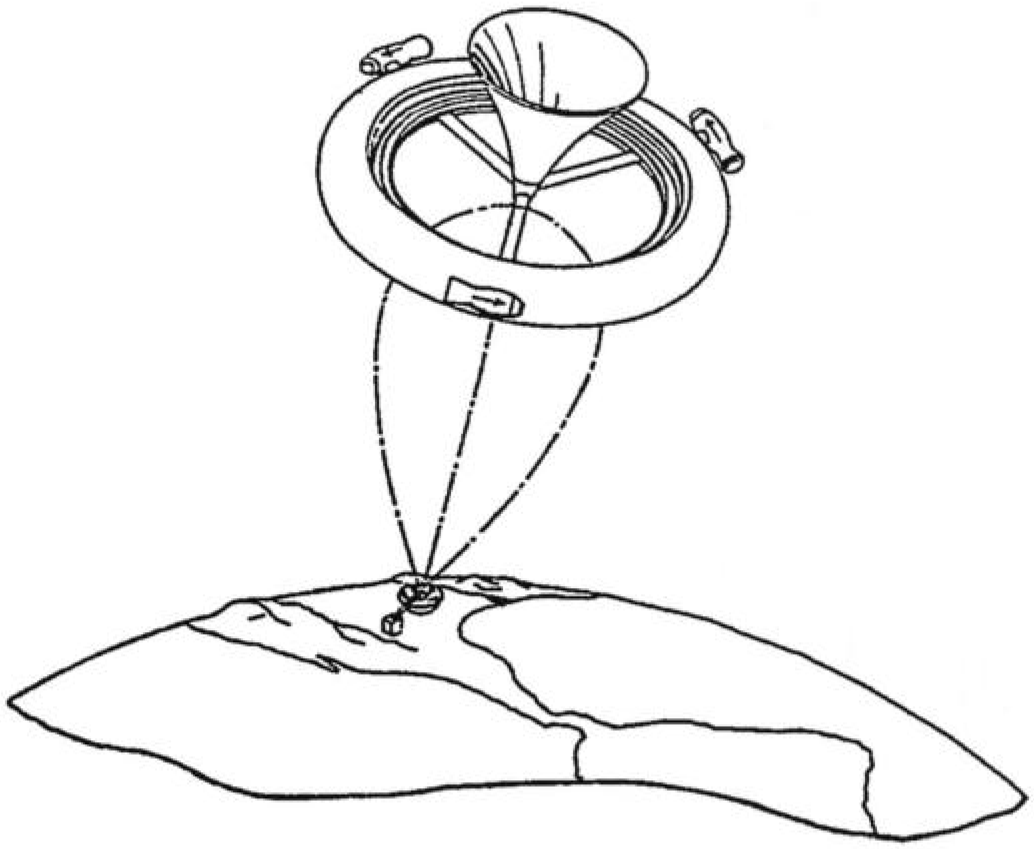
Tesla's plans came to nothing, but a somewhat simpler method of transmitting energy to an aircraft was studied in 1959 when Raytheon investigated the use of a microwave beam to power a small, high-altitude, unmanned helicopter. This was followed in 1964 by a proof-of-concept demonstration and Raytheon hoped to develop this technology into a means of powering satellites or vehicles in near space, but the project went no further.

During the early 1970s, Dr Arthur Kantrowitz (who founded the Avco-Everett Research Lab in Everett, Massachusetts) began to promote the rather different idea of using a laser to power a spacecraft by means of ablation. This would generate a stream of plasma behind the vehicle and create thrust, while eliminating the need for a large onboard propulsion system. The notion of using microwave and laser beams to transmit high levels of power to an aerospace vehicle and convert the energy into propulsive plasma was soon being studied by Professor Leik Myrabo of Rensselaer Polytechnic Institute in Troy, New York.

Myrabo then turned Kantrowitz's idea around, envisaging a series of massive orbital solar energy collectors called Powersats, which would transmit microwaves downwards towards the Earth in tightly focussed



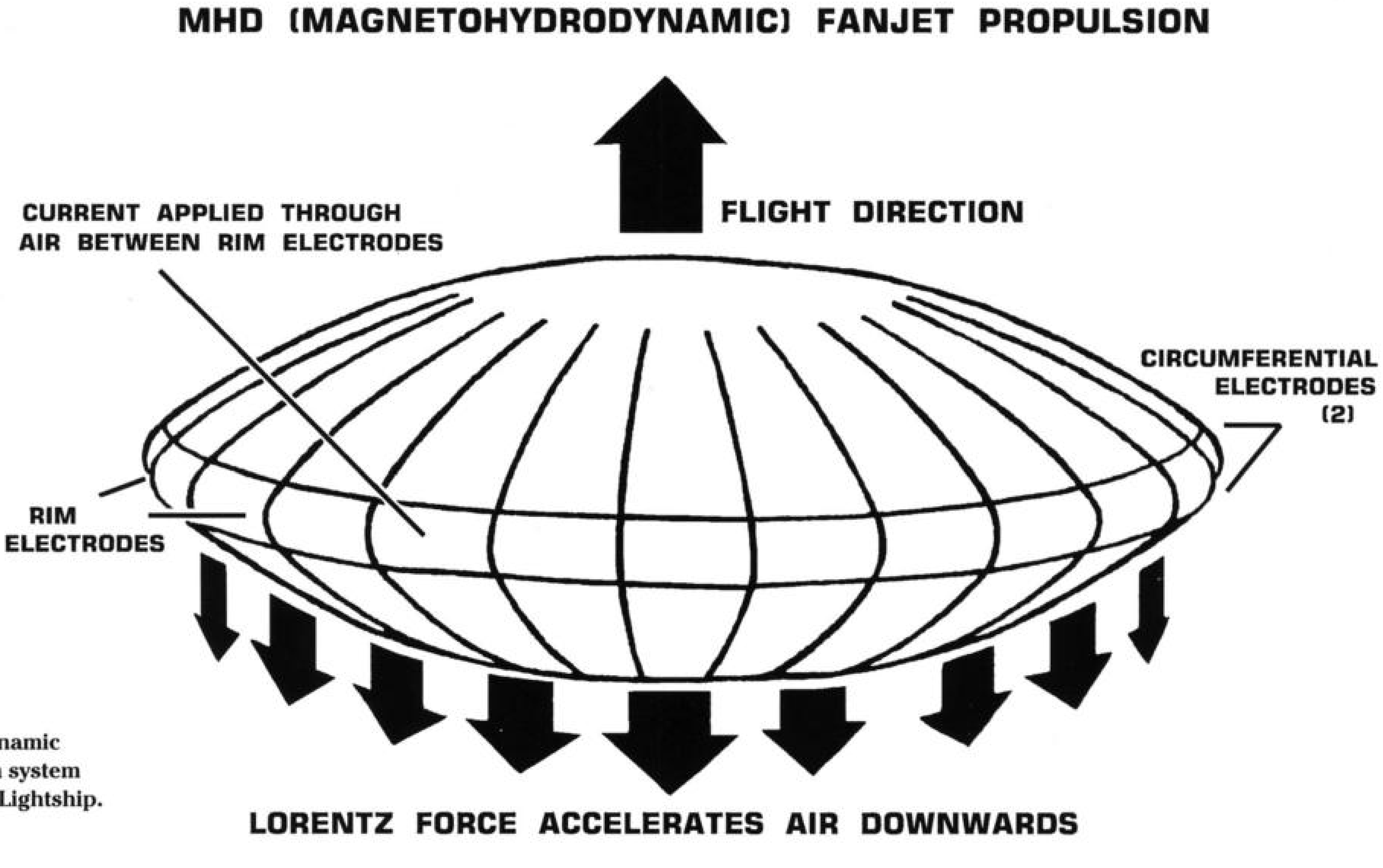
Raytheon orbital satellite designed to receive power from a ground-based microwave transmitter. Raytheon



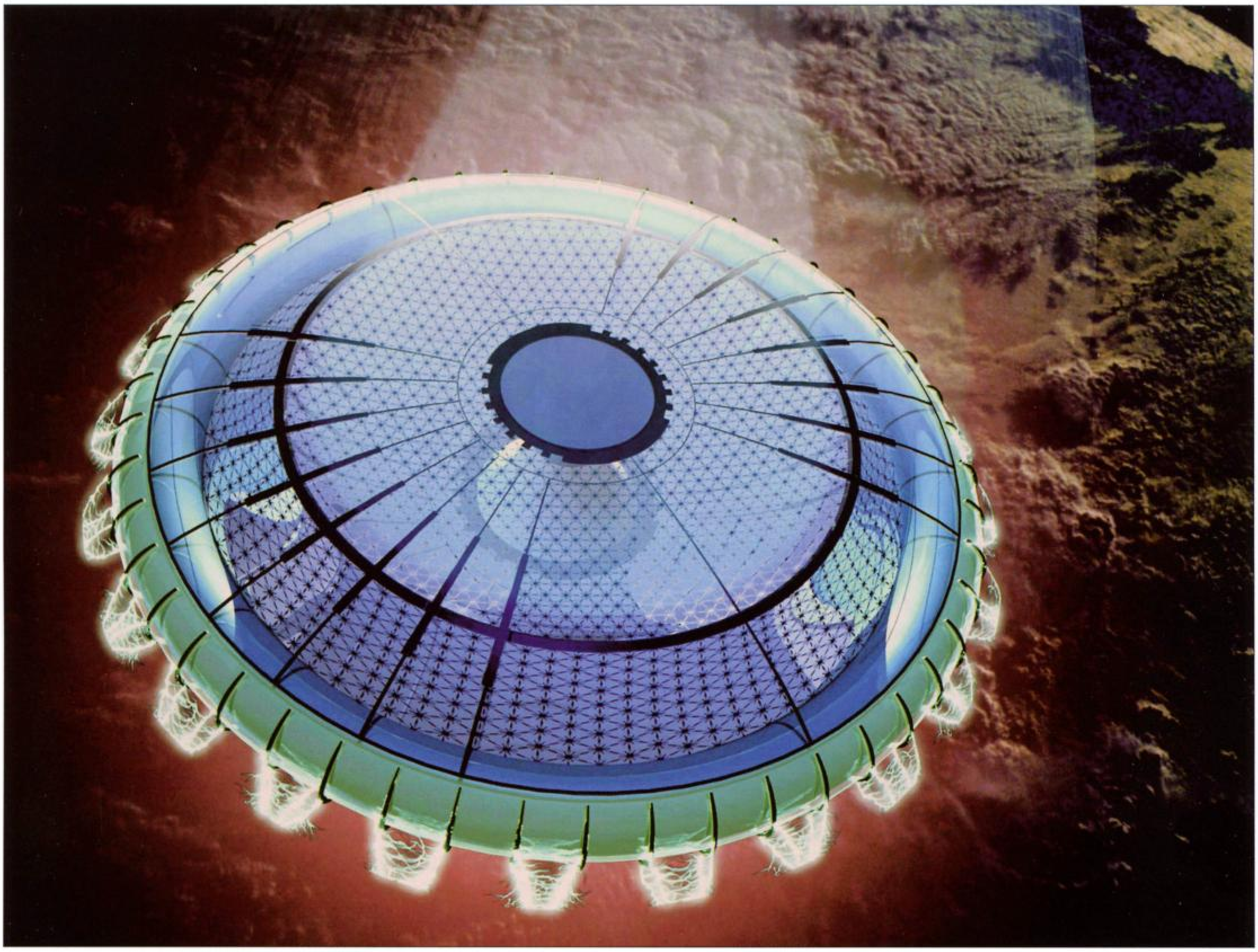
Proposed Raytheon system for power transmission to orbital spacecraft or satellite. Raytheon

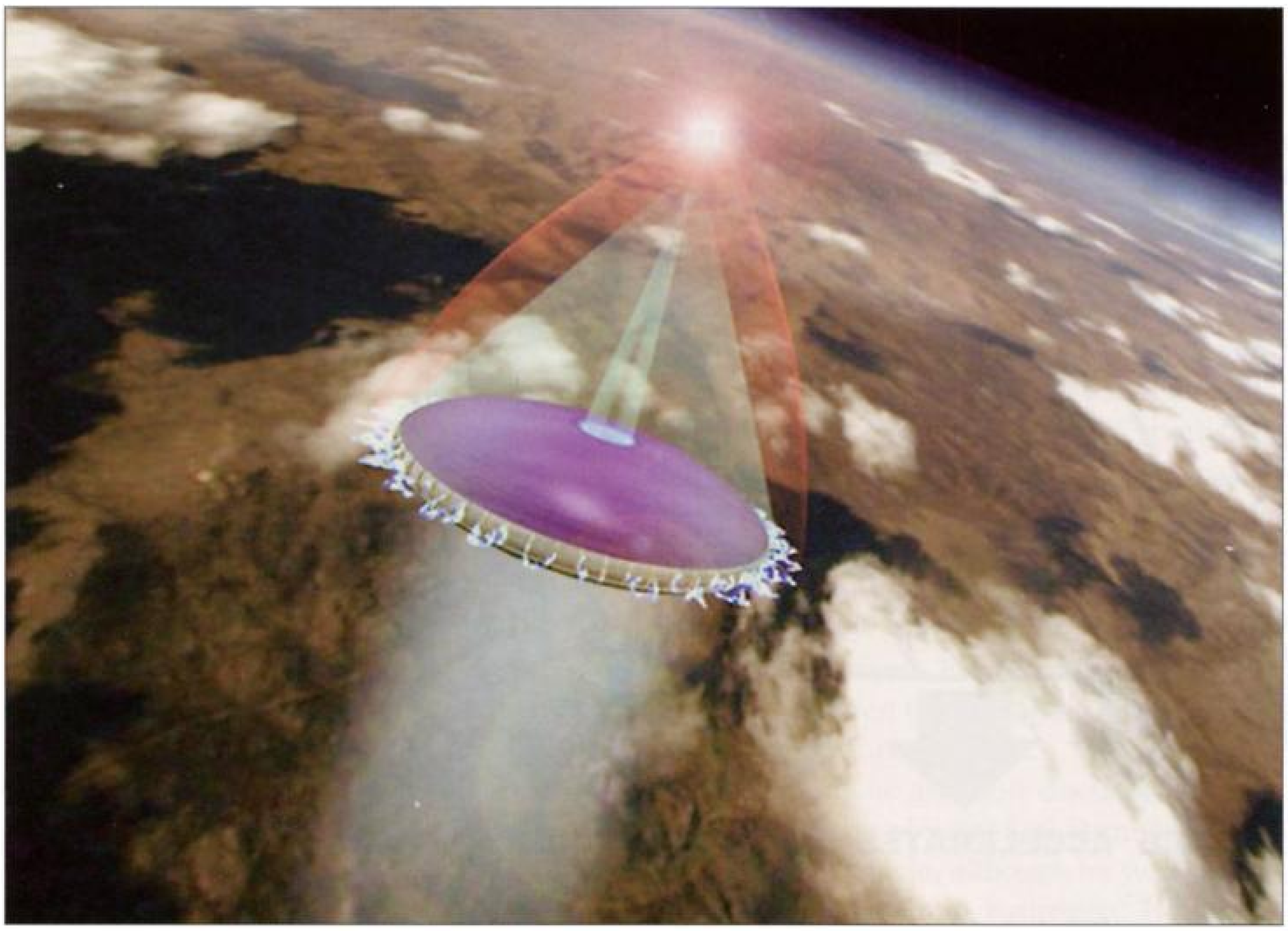
directed beams. These orbital platforms would be located at an altitude of 310 miles (500km), they would have a diameter in excess of 0.62 miles (1 kilometre) and each would be capable of generating at least 20 gigawatts of power. The energy generated would then be utilised by a new form of trans-atmospheric vehicle that Myrabo called The Lightship.

Various designs were studied, but Myrabo soon realised that a lenticular shape was ideal for this concept and he finally settled on a 65ft 7¼in (20m)-diameter flying saucer, with accommodation for twelve passengers. The outer shell of the craft would be fabricated from a thin layer of silicon carbide film, which was transparent to microwave radiation. At the start of a journey the Lightship would lift off the ground, drawing on energy provided by its solar cells or from a space-based infrared laser to ionise the air and move the vehicle by electrostatic discharges. However, this phase of the operation assumes a number of scientific advances which may not have been achieved by the mid-21st century, and the vehicle is more likely to be initially propelled by one or more ground-based lasers produc-


MHD (MAGNETOHYDRODYNAMIC) FANJET PROPULSION
CURRENT APPLIED THROUGH AIR BETWEEN RIM ELECTRODES
FLIGHT DIRECTION
CIRCUMFERENTIAL ELECTRODES (2)
RIM ELECTRODES
LORENTZ FORCE ACCELERATES AIR DOWNWARDS

Magnetohydrodynamic fanjet propulsion system used for Myrabo Lightship. Bill Rose



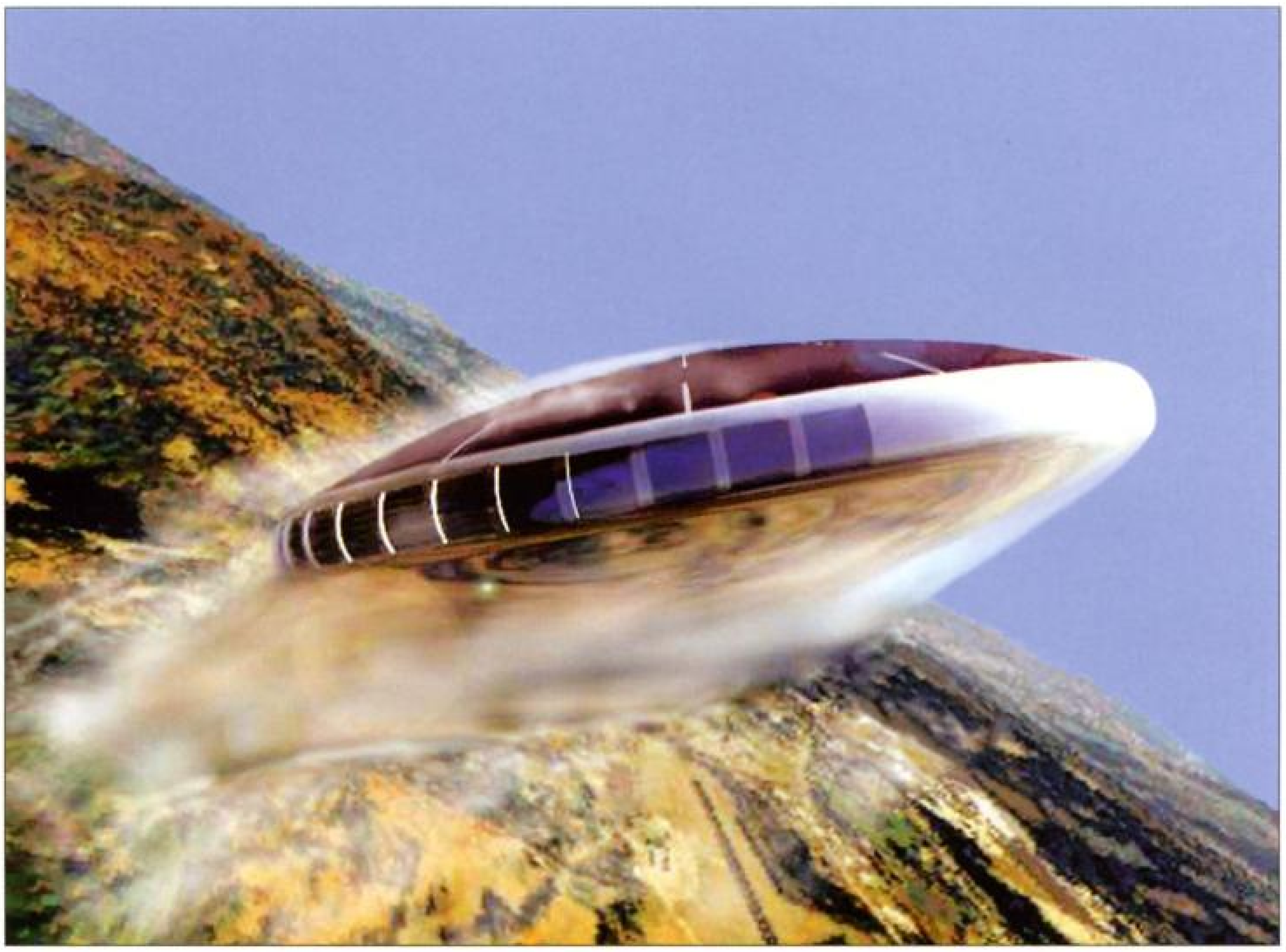


Using power beamed from low earth orbit, a Myrabo Lightship climbs towards the edge of space. NASA

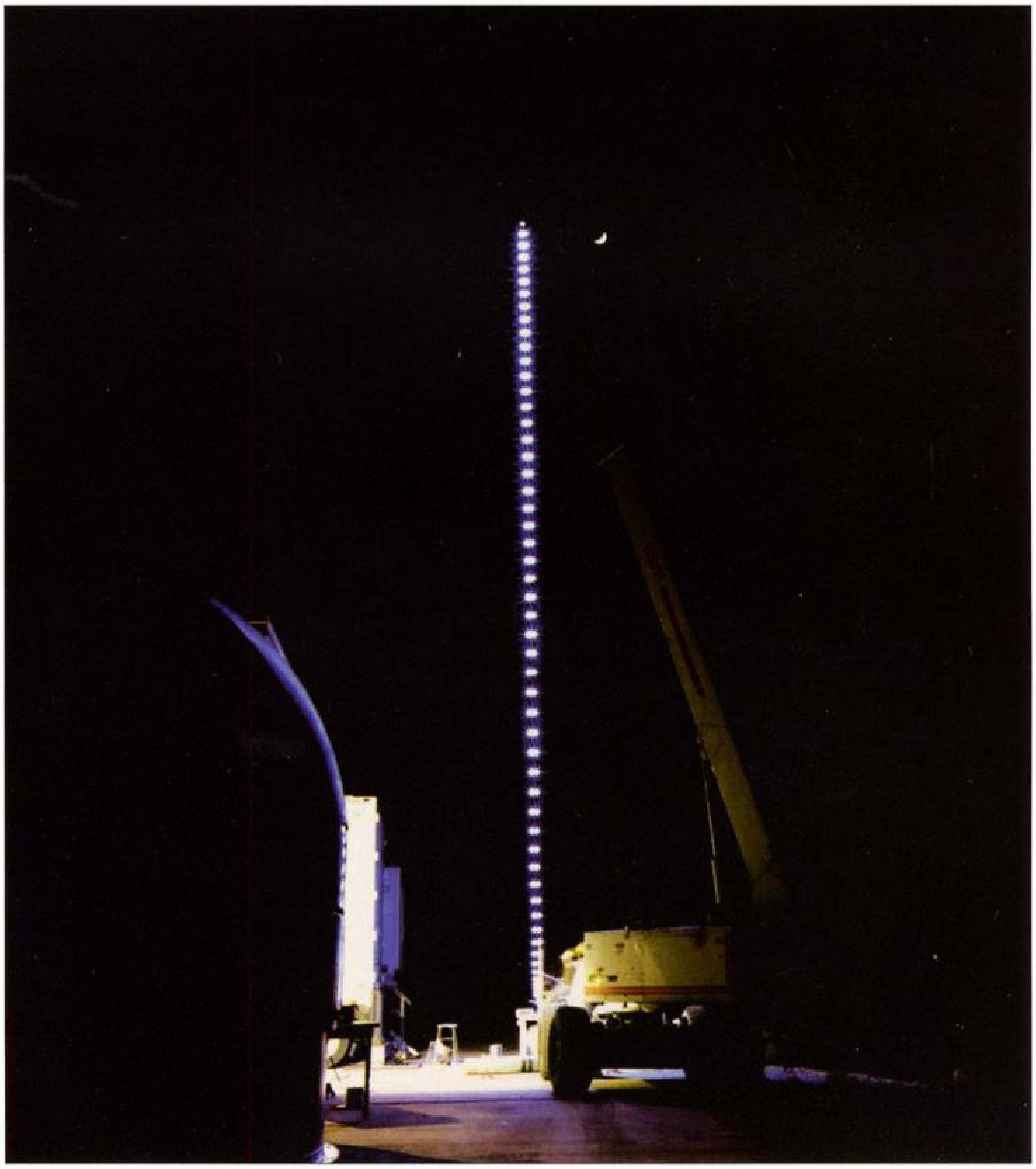
Myrabo Lightship climbs towards low Earth orbit by means of beamed power and the use of airspike technology. NASA

ing plasma energy directly beneath the craft, allowing it to attain a speed of about 50-100mph (80-160km/h).

As the Lightship begins to climb, the controlling system will interface with the nearest Powersat, requesting a tight microwave beam of 4-5 gigawatts. When the beam illuminates the vehicle, antennas (called rectennas) located within the upper shell of the Lightcraft re-direct this energy just beyond the rim of the saucer. In turn, this generates a significantly more intense field of plasma beneath the craft, which is regulated and shaped by superconducting magnets encircling the craft.



In the mid-21st century, a Myrabo Lightcraft lifts off from its launch site. NASA



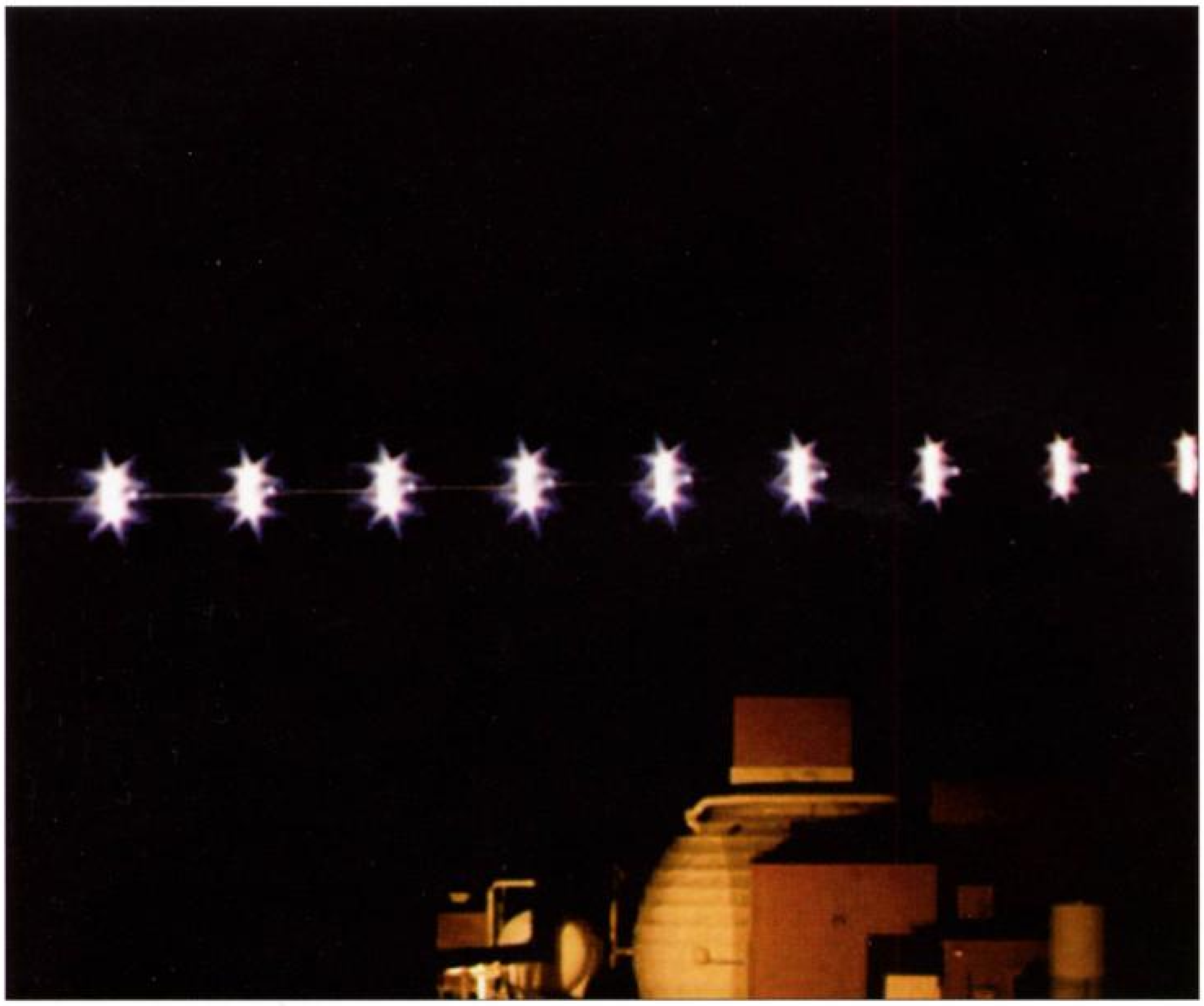
Funded by the USAF and NASA, a number of tests were undertaken by Leik Myrabo and Franklin B Mead of the USAF Research Laboratory (AFRL) during the late 1990s at White Sands to prove the ability to propel a small aluminium test vehicle with a series of laser pulses. This night-time trial achieved a height of 72ft (22m). NASA

Described as a magnetohydrodynamic (MHD) fanjet, this propulsive method is essentially the next step on from Townsend Brown's EHD concept and Osmond's nuclear fusion-powered spacecraft. The Lightship would rapidly reach a velocity of about Mach 3, with Lorentz forces producing thrust, but atmospheric gases have low conductivity so a working system would need to be boosted with a small amount of additional fuel such as hydrogen. At this stage a percentage of the incoming microwave energy would be used to produce a focused point of energy directly before the line of flight called an Air-spike. This would be used to literally cut a path through the atmosphere, allowing rapid acceleration to high hypersonic speeds. Surface heating would be dramatically reduced as the airflow formed a shock wave just beyond the vehicle and theoretically Mach 25, which is orbital velocity, would be possible.

The air-spike technique appears viable because during the early 1990s Dr Myrabo conducted tests in General Electric's hypersonic wind tunnel and succeeded in producing a Mach 10 parabolic shock wave using a plasma torch. Pavel Tretjakov of the Novosibirsk Institute of Theoretical and Applied Mathematics produced similar results with a laser at speeds of Mach 2 and believed the air-spike could operate at orbital speeds. These ideas drew widespread interest within the scientific community and similar research began in several laboratories across the country.

Meanwhile, Professor Myrabo secured funding from the Space Studies Institute, NASA and the USAF to continue his unique research and by 1996 he was developing new more practical ideas involving laser propulsion. Working with Franklin B Mead of the USAF Research Laboratory (AFRL) he began a series of experiments with small 0.88-oz (25-gm) aluminium test vehicles at the White Sands Missile Range (WSMR) in New Mexico. These trials began in 1997 and were conducted using a pulsed 10-kilowatt infra-red carbon dioxide laser borrowed from the US Army.

The test vehicles were normally no larger than 5⅞in (15.0cm) in diameter and were



This page:
Left: **A horizontal laser-driven test flight at White Sands.** NASA

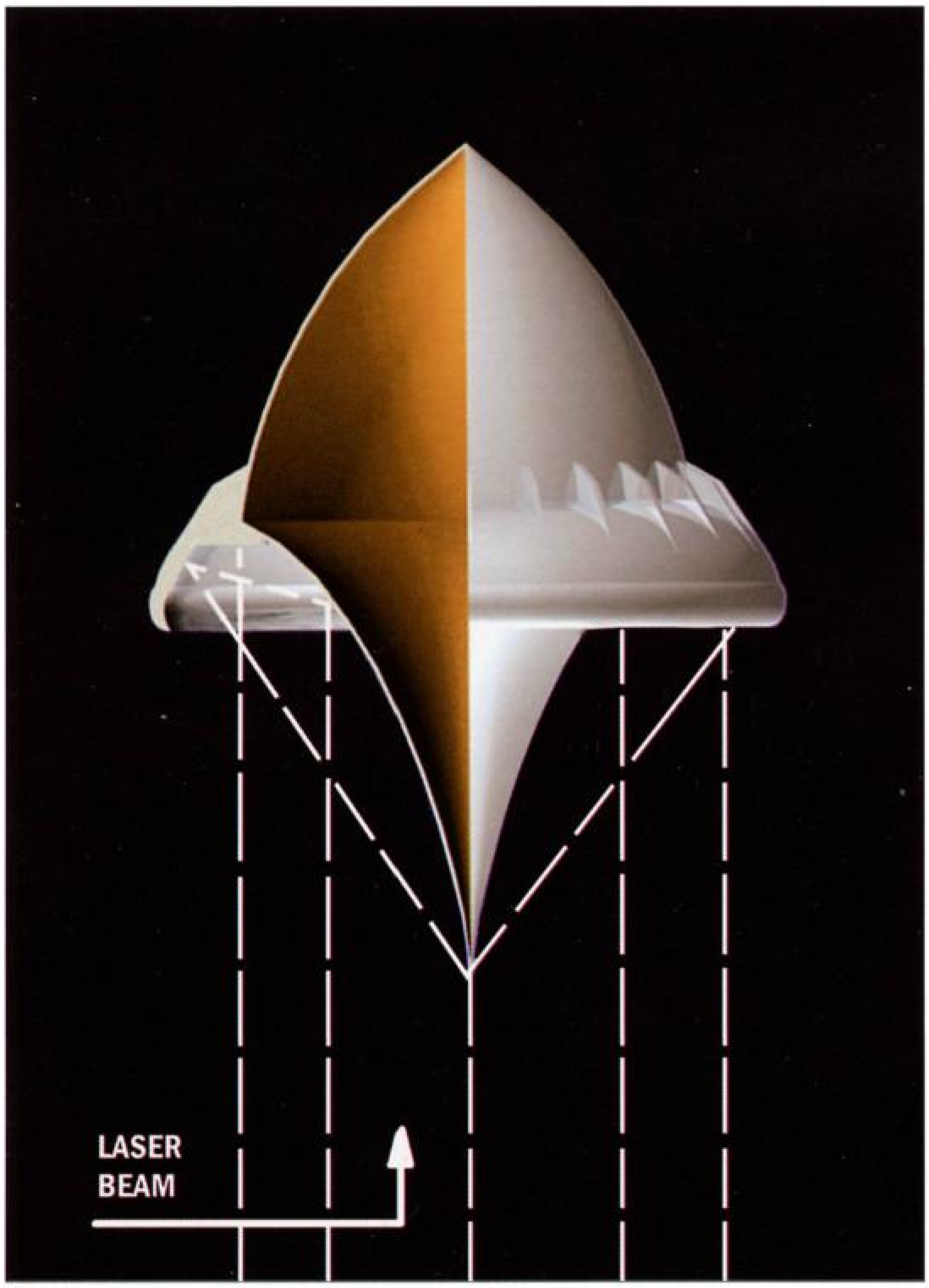
Below left: **Myrabo laser-propelled test vehicle cutaway.** NASA

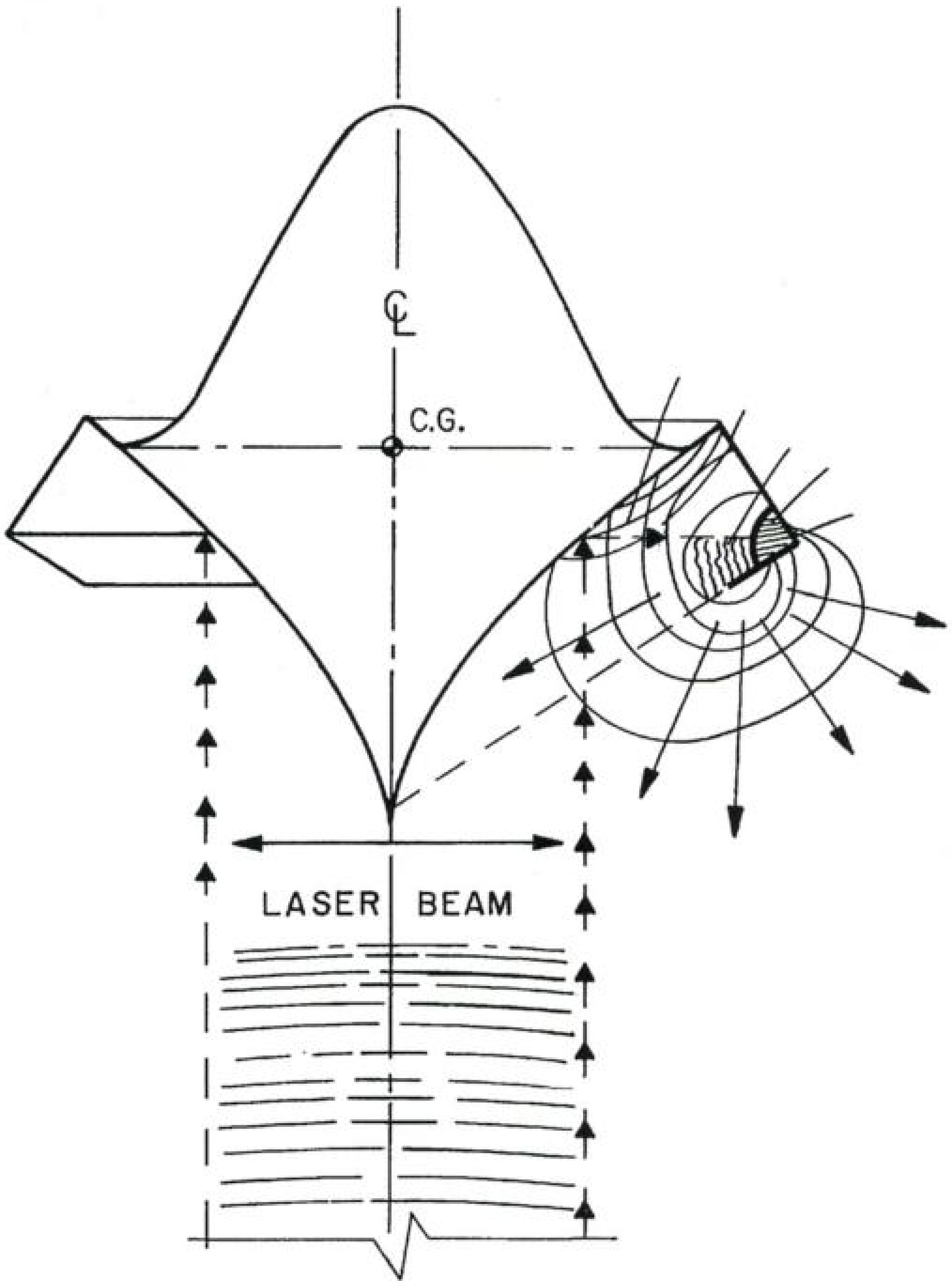
Below right: **Myrabo laser-driven test vehicle diagram.** US Patent Office

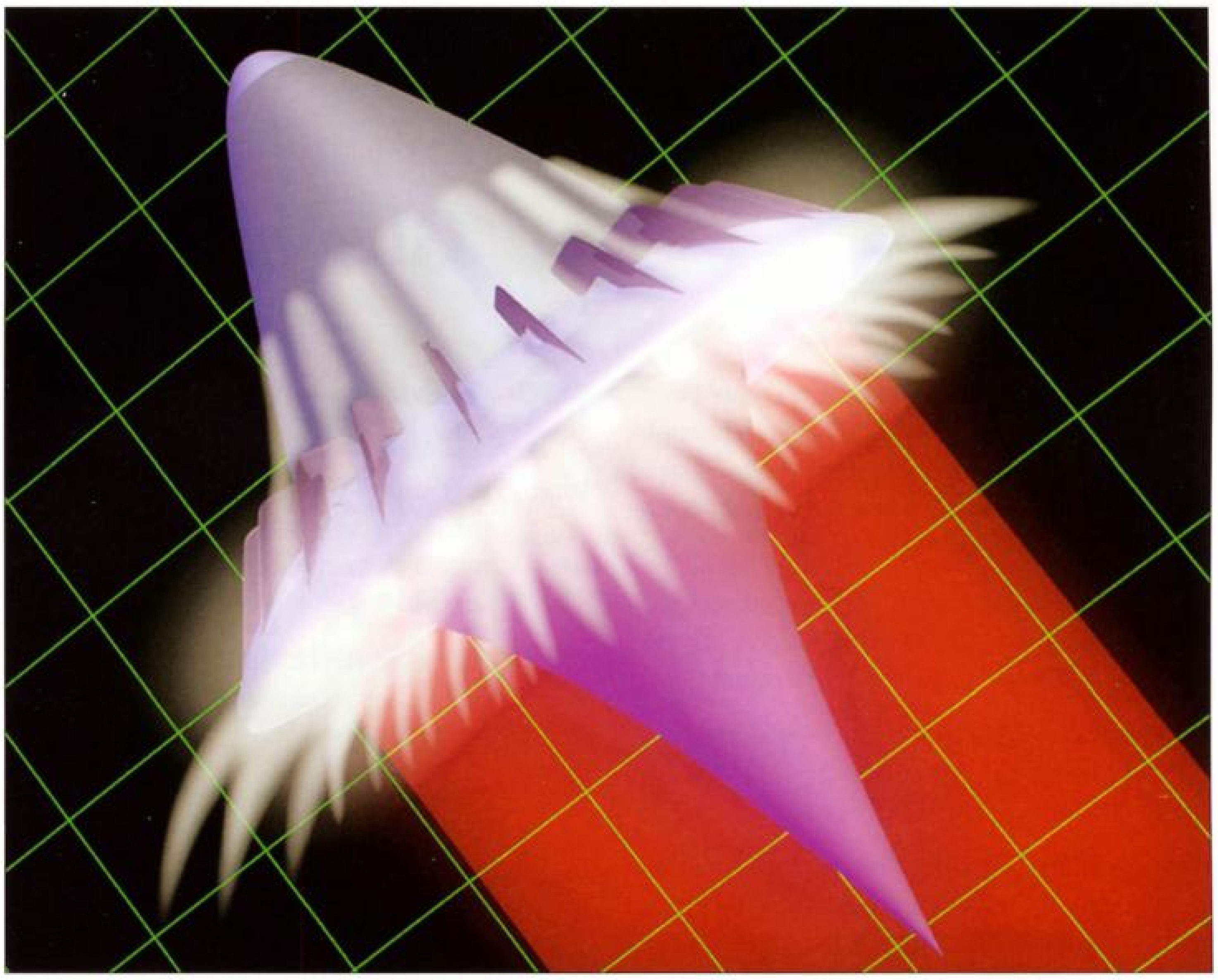
Opposite page:
Top left: **Tregenna Myrabo (Leik Myrabo's daughter), who is manager of Lightcraft Technologies Inc, holds one of the small laser-driven test models at White Sands Missile Range, New Mexico.** Lightcraft Technologies Inc

Top right: **Myrabo Lightcraft artwork.** NASA

Right: **During September 2003, a team of NASA researchers from Marshall Space Flight Center (MSFC) and Dryden Flight Research Center proved that beamed light could be used to power an aircraft and sustain it in flight. Special photovoltaic arrays on the plane, similar to solar cells, receive the light energy and convert it to electric current to drive the propeller motor. In a series of indoor flights at MSFC, a lightweight custom-built laser was used to illuminate the aircraft's solar panels. Photographed with their invention are (from left to right): David Bushman and Tony Frackowiak, both of Dryden; and MSFC's Robert Burdine.** NASA-MSFC







spun up prior to launch with nitrogen gas and then pulsed at the rate of twenty-eight times per second after release. This produced sufficient plasma to lift the test vehicles to around 98ft 6in (30.0m), which was a limit set for reasons of range safety. However, the height limit was extended in October 2000 when an altitude of 233ft (71.0m) was achieved using a small spin-stabilised laser-propelled test vehicle during a flight lasting 12.7 seconds. On this occasion the same 10-kilowatt laser was used and the test was undertaken in conjunction with NORAD to ensure there was no accidental irradiation of passing orbital satellites.

Further tests have been undertaken and Myrabo has suggested the possibility of launching small vehicles to an altitude of 100,000ft (30,500m) using a 150-kilowatt laser followed by a launch to orbital height with a 1-megawatt laser. To achieve this the aviation quality aluminium used to construct the model would be largely replaced by silicone carbide and Myrabo has suggested the possibility of fitting a miniature mirror system to redirect some of the laser energy ahead of the model to create an Air-spike.

This is exciting research and there seems little doubt that vehicles propelled by laser and microwave energy could become a reality within the next fifty years. However, in the case of the Lightship concept it would be phenomenally expensive to establish a series of huge orbital power generation platforms, which also have the potential to be used as weapons. Furthermore, an interruption of the beamed power or a critical component failure within the Lightship could prove catastrophic. That said, it seems likely that Air-spike technology is being developed within the classified domain and may have some near-future military application.

The transmission of power to aircraft reappeared in 2003 when two NASA teams revived ideas first studied by the agency in the 1970s. Engineers and scientists from the Marshall Space Flight Center (MSFC) and Dryden Flight Research Center combined their talents to produce a small propeller-driven model aircraft powered by laser illumination, which was flown indoors at MSFC. The model aircraft was built at Dryden Center (Edwards AFB) by David Bushman and Tony Frackowiak and equipped with small photovoltaic arrays (similar to solar cells) at MSFC. Whether or not this work might eventually lead to a revival of interest in the concepts first promoted by Raytheon in the early 1960s is hard to say at the present time, but the technology could be applied to small UAVs, with the disc providing an ideal shape for collection arrays.

Glossary

Air Spike A focused point of energy created in the path of a vehicle that cuts a channel through the atmosphere and allows rapid acceleration to hypersonic velocity while avoiding thermal stress.

Aspect Ratio The aspect of wingspan to mean chord, usually calculated by dividing the square of the span by the wing area.

Coanda Effect The tendency of a jet stream to flow along a solid surface, which may curve away from the jet axis.

Collective Pitch Flight control (for rotary winged aircraft) that simultaneously adjusts the pitch of all blades used in a rotor to control lift.

Cross Range The distance to a landing site on either side of a spacecraft's re-entry path.

Cyclic Pitch Flight control (for rotary-winged aircraft) that tilts the rotor disc and controls the direction of flight.

DARPA Defense Advanced Research Projects Agency (US).

Ducted Fan Design Enclosed rotor propulsion system.

Electrogravitics Electro-gravitational theory, with possible applications as a field-effect propulsion system.

EHD Electrohydrodynamic propulsion. A proposed system to control the flow of plasma beneath a disc-shaped vehicle, producing thrust.

GETO Ground Effect Take-off. A rolling take-off, initially using ground effect lift.

Ionic Propulsion The application of a high voltage to the exterior of a vehicle, which produces a negative ion field that pulls surrounding air along its flow path.

JPL Jet Propulsion Laboratory – Originally a USAAF department and later a major NASA facility.

Kinaesthetic Control Devised by Charles Zimmerman. The pilot of a small flying platform shifts his body weight to change flight direction.

L/D lift/drag ratio. A measurement of aerodynamic efficiency, with a maximum of about 45:1 for sailplanes.

LUNEX Lunar Exploration Plan – USAF 1961 proposal for a military base on the Moon.

Mach Number Ratio of an air vehicle's true speed to the speed of sound in air at the altitude the vehicle is flying. A vehicle travelling at a Mach number in excess of 1 is considered to be supersonic. At velocities above Mach 5 it becomes hypersonic.

MHD (Magnetohydrodynamic) Fanjet A theoretical propulsive system producing a field of intense plasma beneath a vehicle, which is controlled by superconducting magnets.

MIT The Massachusetts Institute of Technology.

NACA National Advisory Committee on Aeronautics – the forerunner of NASA.

NASA National Aeronautics and Space Administration, created on 1st October 1958 by the Eisenhower Administration.

NERVA Nuclear Engine for Rocket Vehicle Application. A multi-billion dollar US programme to build a nuclear thermal propulsion system with significantly more power than a chemical rocket. Work was undertaken from approximately 1961 to 1973, but development continued in the black domain as Project Timberwind.

OAV Organic Air Vehicle – used by the smallest operational unit.

OKB Opytno Konstrucktorskoe Byuros – Soviet Special Design Bureau concerned with aerospace technology.

Project Horizon US Army 1959 project for a military base on the Moon.

RFGT Radial Flow Gas Turbine – An unusual high-performance pancake-shaped engine, working edge-on during level flight.

RLM Reichsluftfahrtministerium – German Air Ministry.

STOL Short take off and landing.

T/W Thrust to weight ratio.

VTOL Vertical take off and landing.

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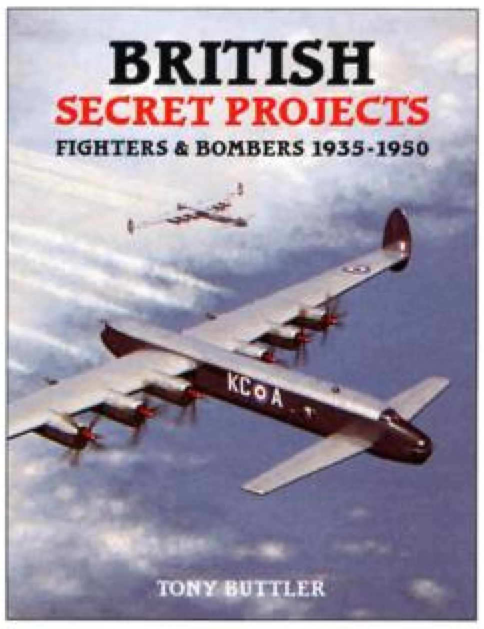
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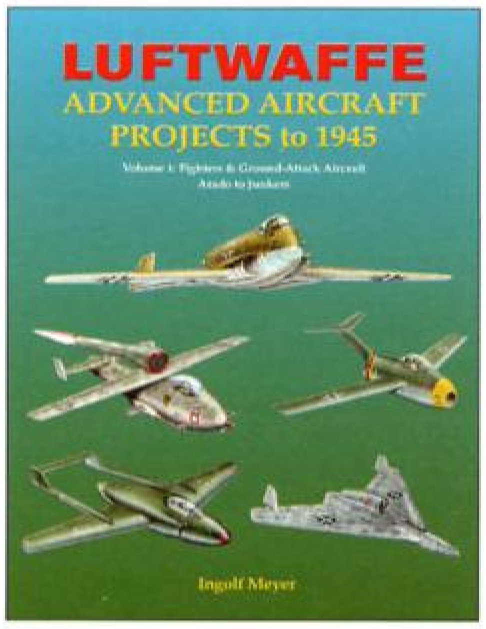
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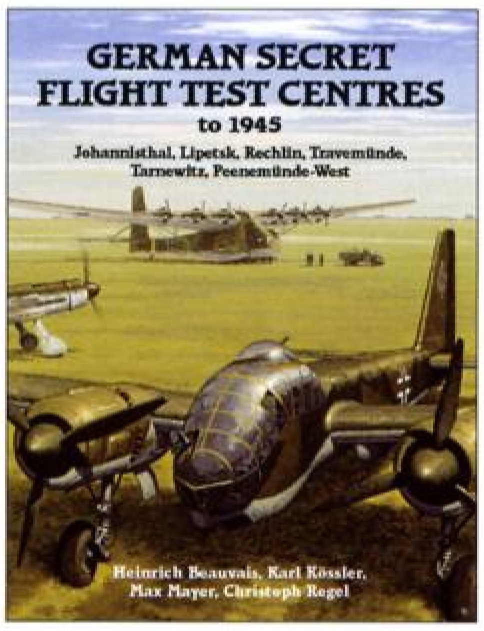
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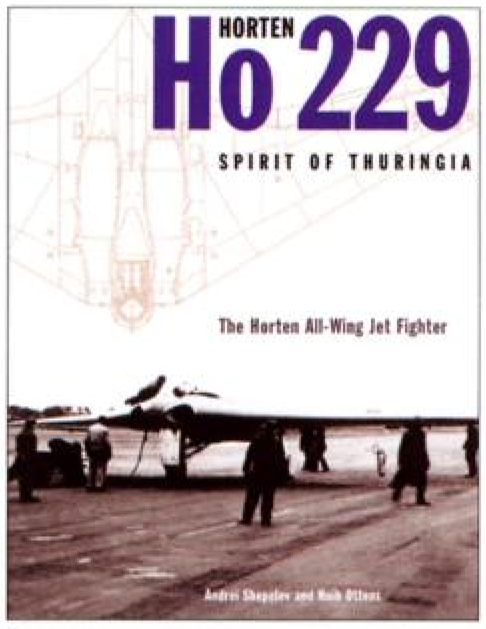
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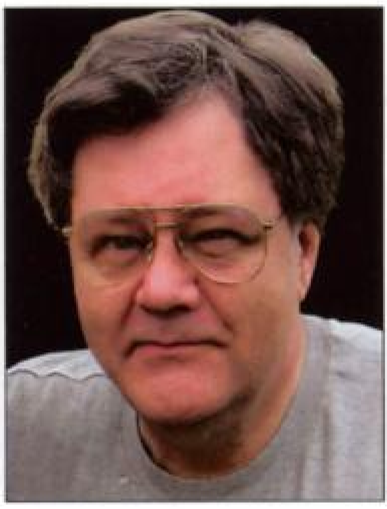

Bill Rose was born in 1948 and grew up in the North London suburbs. He was educated at Buckingham College and the University of Westminster. Bill began his working life as a laboratory technician, became a Fleet Street press photographer and eventually a photojournalist. As a writer, he has worked for many of the well-known science journals, a number of technical publications and various national and provincial newspapers. His principal areas of interest are photography, astronomy, space exploration and aviation. Bill has also undertaken background research for several UK-based TV production companies. He runs a small photographic business located in Norfolk, which specialises in PR work, graphic design and image restoration.

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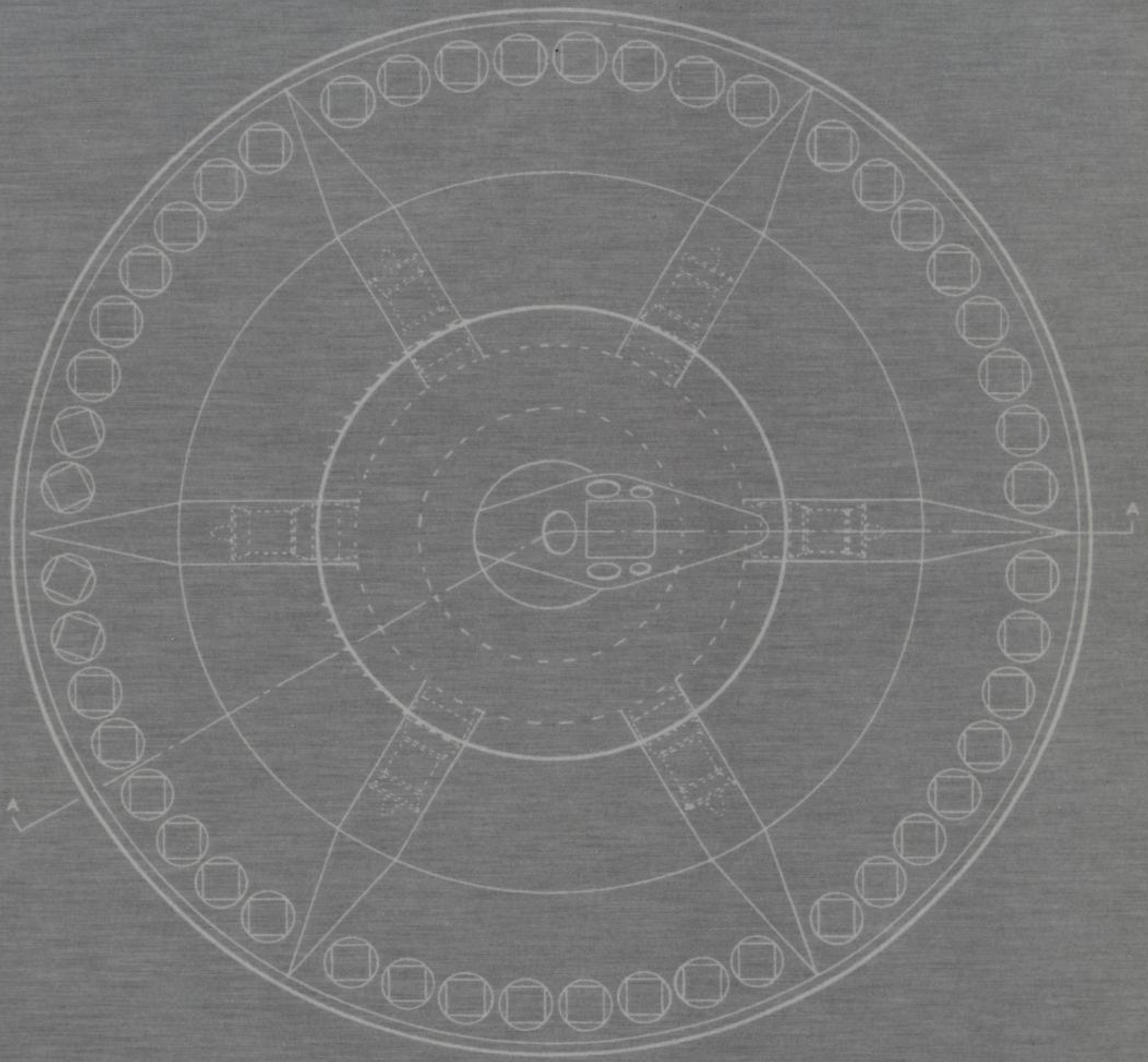

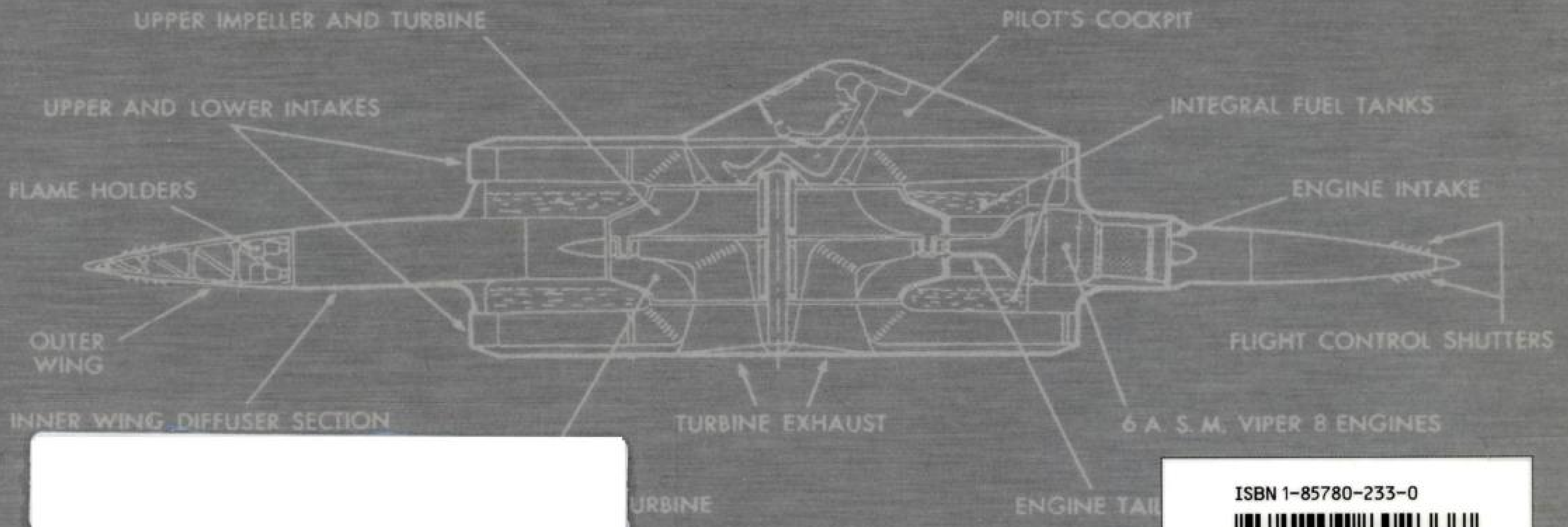
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